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MICHIGAN STATE COLLEGE
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EAST LANSING

THE QUARTERLY BULLETIN

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MICHIGAN STATE COLLEGE
AGRICULTURAL EXPERIMENT STATION
EAST LANSING

C. M. HARDIN, DIRECTOR
R. E. MARSHALL, ASSISTANT DIRECTOR
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PROBLEMS ASSOCIATED WITH CULTIVATED BLUEBERRY PRODUCTION IN NORTHERN MICHIGAN

By STANLEY JOHNSTON
DEPARTMENT OF HORTICULTURE

THE BLUEBERRY was found widely distributed as a native plant in Michigan when the first white settlers arrived, and it soon became a highly prized item in their diet.

There are many species of the blueberry in America. Those of the north-central and northeastern states can be divided into two general groups or types on the basis of growth habit—lowbush and highbush.

Both types occur naturally in Michigan. The highbush is found in the southern part of the lower peninsula as far north as the lower end of Saginaw Bay. The lowbush is found in many places north of that point in the lower peninsula and in the upper peninsula.

HISTORY OF THE LOWBUSH BLUEBERRY IN MICHIGAN

While the lowbush blueberry was originally widely distributed in northern Michigan, its growth and productiveness were curtailed considerably by competition from heavy stands of pine and other trees and shrubs.

After the pine was lumbered, the blueberry plants became very productive. Large quantities of berries were shipped to markets in the middlewest. Then, second-growth timber became larger and competition with the blueberry plants again increased to the point where the crop was no longer of commercial importance.

POSSIBILITIES OF INCREASING LOWBUSH BLUEBERRY PRODUCTION

It has been suggested that certain native lowbush areas in northern Michigan be set aside primarily for blueberry production. This would be accomplished by systematically and carefully burning over these areas every three years to remove other vegetative competition and permit the wild blueberries to produce larger crops.

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Fig. 1. Lowbush blueberries. A very low, spreading variety in the foreground, and a slightly higher one in the background. Most lowbush blueberry plants range from 6 to 12 inches in height.

There are several objections to this policy. Most important of these are the forest fire hazard involved and the impossibility of controlling insects and diseases in such areas, especially the blueberry maggot.

Attempts have been made to grow the lowbush blueberry under cultivation. This can be done without too much difficulty, but the lowbush plant is too low and spreading to be handled easily under cultivation, and the berries are too small and inclined to be soft.

DEVELOPMENT OF THE CULTIVATED HIGHBUSH BLUEBERRY INDUSTRY

Since 1923 a cultivated blueberry industry has been developed in southwestern Michigan with improved varieties of the highbush type. At present, over 2,000 acres are devoted to this crop, and in 1950 the sale of berries and plants amounted to about $1,250,000. There is every indication that the industry will expand to much larger proportions.

TRIAL PLANTINGS OF THE HIGHBUSH BLUEBERRY IN NORTHERN MICHIGAN

While the highbush blueberry did not occur as a native plant in northern Michigan, it seemed advisable to make trial plantings of it

there because of its advantages over the lowbush for commercial culture. Accordingly, beginning in 1933, a total of 60 test plantings were made in widely distributed places in the upper peninsula and the northern part of the lower peninsula. These plantings included all of the standard highbush varieties and many seedling selections.

From these plantings it was learned that the highbush blueberry would succeed in the northwestern part of the lower peninsula if the plantings were made very close to Lake Michigan. For instance, plantings near Ludington and on the Old Mission Peninsula near Traverse City were successful, but plantings a few miles inland were not.

All of the plantings in the upper peninsula failed except three near Houghton. Even in these, only one named highbush variety, Rancocas,

Photograph—K. K. Vining

Fig. 2. A promising hybrid between the lowbush and highbush blueberries. This hybrid is about 18 inches high, has acquired some of the greater size and height of the highbush plant, and some of the larger size and greater firmness of the highbush berry.

was moderately successful. The fact that it is a one-quarter lowbush hybrid may account for its partial success in the north. One highbush seedling, HBS 46, resulting from the blueberry breeding work carried on at the South Haven Experiment Station, proved to be the best variety on trial in the Houghton area. This variety has been named Keweenaw and is described in a companion article in this issue of the *Quarterly Bulletin.*

Apparent reasons for the rather general failure of the highbush blueberry in northern Michigan are:

1. Insufficient length of growing season (number of days between killing frosts) for highbush varieties to develop and mature wood and fruit buds.

2. Killing of wood protruding above the snow level by frequent low late fall and winter temperatures. Much of the supposed greater hardiness of the lowbush blueberry is actually due to protection from snow cover.

3. Breaking of highbush plants from very heavy accumulations of snow. The wood of the highbush plant is more rigid and brittle than that of the lowbush, and therefore breaks easier.

For best performance, the highbush blueberry requires a growing season of about 160 to 165 days. The average length of growing season for the Traverse City-Old Mission Peninsula area is about 154 days; for the Houghton area, 145 days; at Lake City it is 123 days, and for interior parts of the upper peninsula it ranges from 60 to approximately 100 days.

A study of the above data on length of growing season shows clearly why the highbush blueberry succeeded reasonably well on the Old Mission Peninsula; why only two highbush varieties apparently adapted to a shorter growing season succeeded in the Houghton area, and why highbush plantings failed in the interior parts of the upper and lower peninsulas, away from the moderating influence of the Great Lakes and their effect on lengthening the growing season on land adjacent to their shores.

The lowbush blueberry matures its fruit and forms fruit buds for the next year's crop in a considerably shorter growing season than the highbush. Lowbush plants are found in abundance where the average growing season is as short as 60 to 70 days. However, to safely avoid frosts at blossoming time or soon after, and to have sufficient time to harvest most of the crop before early September frosts might occur, a growing season of about 120 days is required.

SELECTION AND BREEDING PROGRAM TO FIND VARIETIES SUITABLE FOR NORTHERN MICHIGAN

It was early realized that neither selections of the lowbush blueberry nor the standard highbush varieties would be entirely satisfactory for commercial blueberry culture in northern Michigan. It seemed that selected hybrids of the two might prove to be satisfactory, or dwarf forms of the highbush might be of value, provided they would produce satisfactory crops in the shorter growing season in northern areas.

Fig. 3. A row of plants of an excellent hybrid between the lowbush and highbush blueberries. These plants range from 18 to 24 inches in height. They are upright and high enough to be easy to cultivate and harvest, and yet low enough to be well covered with snow during the usual northern Michigan winter. The shoots are upright but pliable enough to be pressed down and covered by snow without breaking.

Field trips were made in lowbush blueberry areas of northern Michigan in the summers of 1925, 1926, 1931, and 1932, looking for superior lowbush varieties. In all, 46 selections were made and moved to the South Haven Experiment Station where they were established and later crossed with various highbush varieties.

Unfortunately, the undesirable characteristics of the lowbush blueberry, including low habit of growth, and small size and softness of berry were almost completely dominant in the first generation seedlings. Also, about 98 percent of the seedlings produced dark-colored berries, while light blue color is much preferred.

Somewhat better results were obtained in the second generation. Several thousand seedlings of the third generation are just coming into production and there is some indication that improved hybrids will be found in this group.

To date nearly 25,000 seedlings have been brought into production and carefully examined. From these, 26 hybrids between the lowbush and highbush and 39 dwarf forms of highbush, have been selected for trial in northern Michigan. Plants of many of these are coming into production in the Houghton area. It is believed that some of these selections may serve as a basis for growing blueberries under cultivation in northern Michigan.

RECOMMENDATIONS

For the present, only the Rancocas and Keweenaw varieties can be recommended for trial in northern Michigan. These varieties no doubt will do best in areas very close to the Great Lakes where the growing season is longer than farther inland. Some of the hybrids between the lowbush and highbush will undoubtedly be better suited than Rancocas and Keweenaw to areas having shorter growing seasons. The best of these hybrids will be released as rapidly as possible, probably within a very few years.

Rancocas matures earlier than Keweenaw. Growing both varieties will provide berries over a season of about six weeks when the plants are full grown.

The prospective blueberry grower in northern Michigan should keep in mind that the blueberry plant must have a very acid soil (pH between 4.0 and 5.1) for successful growth and production. Also the soil should be well supplied with organic matter and retentive of moisture. The site should be as frost free as possible. Observance of these fundamentals is essential for success.

THE KEWEENAW BLUEBERRY: A VARIETY FOR TRIAL IN NORTHERN MICHIGAN

By STANLEY JOHNSTON
DEPARTMENT OF HORTICULTURE

WHILE the highbush blueberry has never been found growing as a native plant in Michigan north of the lower end of Saginaw Bay, it seemed advisable to make test plantings of standard highbush varieties and seedlings in northern Michigan.

Accordingly, beginning in 1933, sixty such test plantings were made in widely distributed places in the northern part of the lower peninsula and in the upper peninsula.

It was learned from those tests that the best standard highbush varieties would succeed moderately well near Ludington and on the Old Mission Peninsula, if the plantings were made very close to Lake Michigan. In other places in the northern part of the lower peninsula and in the upper peninsula, only three test plantings of the highbush blueberry were partially successful. These were all in the Houghton area of the Keweenaw Peninsula.

The best highbush varieties as grown in southwestern Michigan failed in the Houghton area. One named variety, Rancocas, succeeded fairly well, possibly because of having lowbush in its parentage.

Of all the highbush varieties tested in northern Michigan, HBS 46, a selection made from the blueberry breeding plots at the South Haven Experiment Station, proved to be best. This variety is being named Keweenaw for the Keweenaw Peninsula where it made its good record.

Keweenaw is being released for trial in northern Michigan. It is not recommended for growing in commercial highbush blueberry areas in southwestern Michigan or other places where standard highbush varieties do well. Keweenaw cannot compete with the best varieties in these areas, but it has shown a special adaptability to the shorter growing seasons of northern areas.

Even in northern Michigan, Keweenaw should be tried principally in areas close to the Great Lakes having an average length of growing season of 145 days or more. It may not succeed where the growing

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season is shorter. Standard highbush varieties of southwestern Michigan require a growing season of 160 days or more for best growth and production.

Hybrids between the lowbush and highbush blueberries no doubt will be available within a few years for areas having an average length of growing season of less than 145 days.

Fig. 1. A cluster of the Keweenaw blueberry.

Keweenaw originated at the South Haven Experiment Station as an open-pollinated seedling of Katharine in 1927. It was first sent to northern Michigan for trial in 1936.

The bush of Keweenaw is upright, vigorous, hardy, and productive. It has been free from leaf spot and other diseases. It grows too tall for

maximum snow protection in northern Michigan, but Roy Johnson, cooperator in blueberry test plantings in the Houghton area, has been able to keep the bushes lower and more spreading by the careful use of a heading-back type of pruning, thereby insuring more complete snow coverage and protection.

The berries are light blue, large, nearly round, firm, and of excellent flavor. The picking scar is rather large. They usually mature in August in northern Michigan, and even later in some seasons. The season of maturity can be made a few days earlier by heavier pruning.

Interested persons should write to the South Haven Experiment Station, South Haven, Michigan, for information about obtaining plants of the Keweenaw variety. Plants will not be available for distribution until the spring of 1952.

EVALUATION OF CONCENTRATE SPRAY COVERAGE ON LARGE APPLE TREES BY MEANS OF LEAF PRINTS

By G. C. KLINGBEIL and ARTHUR E. MITCHELL
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SINCE the beginning of power spraying for the control of pests on fruit trees, large volumes of water have been used to distribute small quantities of spray chemicals evenly throughout the tree. With the development of airblast sprayers, however, this method of spray application is gradually being replaced by concentrate sprays.

Concentrate spraying is merely the application of spray chemicals concentrated from two or more times the conventional dilution in a liquid dispersing agent such as water or oil. This method of application differs from conventional spraying in that a small quantity of the concentrated liquid spray is distributed in droplet form into an airblast created by the sprayer which spreads the droplets of spray evenly throughout the tree.

Brann (1), Burrell (3), Mitchell (9), Parker (11), Winter and Young (12), and others have reported favorable results from the use of concentrate sprays for the control of pests on fruit trees. Certain questions, however, have arisen as to: a) the most desirable spray concentration to use for economic pest control, b) the relation of the spray concentration to the amount of actual spray chemical deposited on the plant parts, and c) the uniformity of distribution of the spray chemicals throughout the tree when applied in concentrate form.

With these questions in mind an experiment was conducted to determine the distribution and the relative amounts of spray chemicals deposited on leaves in various locations of large, moderately pruned bearing Delicious apple trees using two times (2x) and four times (4x) the conventional spray concentrations.

MATERIALS AND METHODS

A block of 32 mature 24-year-old large bearing Delicious apple trees located at the Graham Experiment Station of the Michigan State College, near Grand Rapids, was selected for this study.

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The trees were in good vigor, fairly uniform in size, moderately pruned, and growing in sod. The block was planted so that it contained six rows of trees spaced 40 by 40 feet. To facilitate spraying, the block was divided into two plots of three rows, one plot containing 15 trees and the other 17 trees.

Two spray treatments, one of 4x (four times conventional concentration) and a second of 2x (two times conventional concentration) were used throughout the season, the 2x concentration serving as the control treatment. The fungicide application for the control of apple scab (*Venturia inaequalis* [Cke.] Wint.) included two pre-blossom sprays and one post-blossom spray of wettable sulfur plus three cover sprays of ferbam. The first scab spray was applied at the time the buds were in full pink, and subsequent sprays were continued for this pest at 7- to 14-day intervals through the third cover on June 29, 1950. Three applications of parathion were made at the times suggested for the control of curculio, (*Conotrachelus nenuphar* Herbst) and red-banded leaf roller (*Argyrotaenia velutinana* Walker) (8) and three DDT sprays were used for the control of first brood codling moth (*Carpocapsa pomonella* Linnaeus) (8). Two cover sprays of lead arsenate and hydrated lime were applied for the control of apple maggot, (*Rhagoletis pomonella* Walsh) the last application being made August 7, 1950 to aid also in controlling second-brood codling moth.

All spray applications were made with a Model 36 Speed Sprayer equipped with Speed Mist Nozzles[1]. The discharge of the sprayer was so designed that the bank of nozzles on one discharge manifold delivered twice as much spray as the other, 12 gallons and 24 gallons per minute, respectively. The nozzles on each manifold were arranged so that two-thirds of the spray was discharged into the upper one-third of the tree. The rate of travel of the sprayer during all spraying operations was 2.25 miles per hour, which resulted in an application rate of 3 to 3.25 gallons per tree for the 4x treatment and 6 to 6.5 gallons per tree for the 2x treatment. Thus all trees in both treatments received the same amount of actual spray chemicals per application. It should be mentioned that when conventional dilute sprays were used these trees received 12 to 14 gallons prior to first cover and 15 to 18 gallons when in full leaf. The rate of travel of the sprayer was controlled by a tractor-mounted speedometer[2].

[1]Manufactured by the John Bean Division of Food Machinery and Chemical Corporation, Lansing, Michigan.

[2]A product of the Frank Manufacturing Company, Inc., Mentone, Indiana.

The spray coverage and the relative amount of spray chemical deposited on the leaves in various sections of the trees by the two spray treatments were determined by making prints of leaves immediately following the second application of lead arsenate. This technique was first described by Hamilton (4) and was later used by Brann (2) and Klingbeil (5) with slight modifications.

For spray coverage and spray deposit studies, leaf samples were taken from single trees in each of the two spray treatments. These trees were approximately 22 feet high with a 30-foot spread and were typical in size and density of the remaining trees in the spray treatments.

The method of obtaining leaf samples was as follows: Six locations were selected on each tree for sampling. These areas included the outer periphery at heights of 5 to 6 feet, 12 to 14 feet and 18 to 20 feet and at these same heights within the periphery for a depth of 6 to 8 feet. Five spurs including the whorl of leaves were picked randomly at each of the six locations on each tree. In each case the portion of the tree selected for taking spur leaf samples was an area not directly in front of the discharge unit of the sprayer as it passed the tree.

The samples of spurs were brought into the laboratory; one spur was selected randomly from each sample of five spurs; the whorl of leaves was removed from the spur, and prints were made of the leaves (5). The prints included the upper and lower surfaces of the leaves.

Photographs were made of each print of leaves and these in turn were composited into single photographs which included the prints of leaves from each tree (Figs. 1 and 2).

In order to determine the effectiveness of the spraying program using 2x and 4x concentrations throughout the season, 100 apples were selected randomly from the harvested fruit of each tree in each plot at the time of picking. These fruits were examined individually for the presence of apple scab, codling moth and spray russeting.

RESULTS

The distribution and relative amounts of lead arsenate on the leaves of bearing Delicious apple trees resulting from two spray applications made at 2x and 4x concentration are shown in Figs. 1 and 2. A comparison of the leaf prints shows that more lead arsenate was deposited on the leaves by the 4x spray applications than by the 2x treatment.

Fig. 1. A composite of leaf spur prints from a heavily pruned large Delicious apple tree sprayed with a 4x concentrate spray concentration of lead arsenate; (21) upper side and (22) lower side of leaves, top periphery; (23) upper side and (24) lower side of leaves, middle periphery; (25) upper side and (26) lower side of leaves, lower periphery; (27) upper side and (28) lower side of leaves, top interior; (29) upper side and (30) lower side of leaves, middle interior; (31) upper side and (32) lower side of leaves, lower interior.

Fig. 2. A composite of leaf spur prints from a heavily pruned large Delicious apple tree sprayed with a 2x concentrate spray concentration of lead arsenate; (9) upper side and (10) lower side of leaves, top periphery; (11) upper side and (12) lower side of leaves, middle periphery; (13) upper side and (14) lower side of leaves, lower periphery; (15) upper side and (16) lower side of leaves, top interior; (17) upper side and (18) lower side of leaves, middle interior; (19) upper side and (20) lower side of leaves, lower interior.

It is also evident that the amount of lead arsenate deposited on the leaves of the inner portions of the tree by the 4x treatment, Fig. 2 (27 to 32), was almost equivalent to the amount of lead arsenate deposited on the leaves of the outer periphery of the tree by the 2x treatment, Fig. 1 (9 to 14). Furthermore, in each spray treatment the leaves located within the periphery of the tree had a lighter deposit of lead arsenate than those of the outer periphery. However, the amounts of lead arsenate deposited from the top to the bottom of the trees of the two spray treatments (Figs. 1 and 2) was quite uniform.

It is also shown by the leaf prints that the deposit of lead arsenate was greater on the lower surface than on the upper surface. This was due to the angle in which the spray liquid was blown into the tree by the sprayer.

There was very little difference in the amount of apple scab and codling moth injury on the fruit of the two spray plots at the time of harvest (Table 1). Also, neither of the spray treatments resulted in excessive fruit russeting.

Table 1—Percent of codling moth, apple scab and russet injury on harvest fruit of Delicious apple trees sprayed throughout the growing season of 1950 with spray chemicals two times (2x) and four times (4x) conventional applications.

Spray treatment*	Number of trees	Percent russet	Percent scab	Percent codling moth	Total number fruit
4x	17	0.41	1.31	2.08	1683
2x	15	1.22	2.25	4.49	1472

*Applications made with Model 36 Speed Sprayer equipped with Speed-Mist Nozzles.

DISCUSSION

It has been reported (1, 3, 8, 10, 11) that sprays applied in concentrate form result in a greater deposit of spray chemical than when conventional spraying methods are used. From the illustrations of spray deposit in this study (Figs. 1 and 2) it appears that the spray applications of 4x concentration result in a greater deposit of spray chemicals than 2x mixtures, when equal amounts of spray chemical are applied per tree. These findings would indicate the possible reduction of the amount of chemicals applied per tree when using 4x concentrations.

An important factor not to be overlooked when reducing the amount of chemicals to be applied per tree per application in concentrate form is proper adjustment of the sprayer to give uniform distribution. When the sprayer is improperly adjusted, the reduction in spray liquid may result in insufficient spray chemicals being deposited in certain portions of the tree for economic pest control. The possibility of this happening is greater when using small airblast sprayers than when using sprayers with high air-volume capacity, or when using high concentrations such as 10x and correspondingly small quantities of spray per tree.

The value of pruning to obtain good spray coverage can not be overlooked. Pruning of large apple trees may improve quality of fruit by increasing size and improving color as described by Marsh (6), Marshall (7) and Murneek (10). This type of pruning also makes possible better penetration of spray into the tree and more uniform spray coverage throughout the tree. It was felt by the writers that the trees used in this experiment were pruned properly to permit good coverage from concentrate spray applications and to increase fruit size without any appreciable reduction in yield.

As stated by Burrell (3), Mitchell (8) and Winter and Young (12), the possible reduction in the quantity of spray chemicals used in the seasonal spraying program is one of the primary advantages in using concentrate sprays. In this experiment the quantity of actual spray chemicals applied per tree per application through the first cover was equivalent to the amount used in conventional spraying. However, for the remainder of the season when the trees were in full leaf the amount of actual spray chemicals was approximately three-fourths that which would be used ordinarily in conventional spraying. From the study of spray deposit, Figs. 1 and 2, there is indication that the amount of actual spray chemicals used in the 4x treatment could have been reduced even more with little sacrifice of economic pest control. However, more experimental evidence seems necessary to better establish concentrate spray deposits with economic pest control.

SUMMARY

The use of 2x and 4x spray concentrations applied with a Speed Sprayer on large, moderately pruned Delicious apple trees throughout the season gave commercial control of apple scab and codling moth with very little fruit russeting.

The method of spray applications of both the 2x and the 4x spray treatment resulted in uniform spray coverage in all parts of the tree as was illustrated by prints of leaves from the sprayed trees. However, the buildup of spray deposit on the leaves of the trees of the 4x treatment was greater than on the leaves of the trees of the 2x treatment.

There was no saving of spray chemicals by concentrate applications through the first cover spray. Beginning with the second cover and for the remainder of the season the amount of actual spray chemical applied per tree per application was approximately three-fourths that suggested for conventional applications.

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GRADING APPLES IN THE ORCHARD[1]

By H. P. GASTON[2] and J. H. LEVIN[3]

DEPARTMENTS OF HORTICULTURE AND AGRICULTURAL ENGINEERING AND U. S. DEPARTMENT OF AGRICULTURE

IN THE BUSINESS of growing apples, profits depend to a considerable extent on how quickly and carefully the crop is handled, and how effectively it is graded. Growers constantly seek methods and machines that will enable them to do a better job. The work here reported indicates that sorting fruit with a mobile unit is one way of accomplishing this end.

Grading fruit in the orchard is by no means a new idea. Forty years ago practically all of the commercial apple crop was hand-packed in the field on portable sorting tables. With the development of power-driven graders, apple sorting operations were moved into stationary packing houses. Although this system has many advantages it does involve considerable handling under circumstances that make mechanical injury almost inevitable.

A study of a modern orchard grader was undertaken to obtain answers to the following questions:

1. Will the use of a mobile orchard grader reduce the amount of bruising which would otherwise occur during handling and grading operations?
2. Will the use of such machines enable growers to handle their fruit more rapidly and economically than would otherwise be possible?
3. Will the use of mobile graders increase net returns?

METHOD

The mobile orchard grader used in the trials consisted of a feed belt, an eliminator section, a sorting belt and a filling station. The moving parts were driven by a 1 h.p. gasoline engine. The entire assembly was mounted on 3- by 4-inch skids that made it possible

[1]A report of a study made under the Research and Marketing Act of 1946. Departments of Agricultural Engineering and Horticulture, Agricultural Experiment Station, Michigan State College, and Bureau of Plant Industry, Soils and Agricultural Engineering, U.S.D.A. Cooperating.

[2]Department of Horticulture, Michigan State College.

[3]Associate Agricultural Engineer, Bureau of Plant Industry, Soils, and Agricultural Engineering, U.S.D.A.

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to move it readily. The unit was 14 feet long and weighed approximately 450 pounds (Fig. 1).

The grader was tested during the 1949 and 1950 apple harvest seasons and was used to field-grade 7,852 bushels of apples. McIntosh, Jonathan, Delicious and Northern Spy were the varieties included in the tests (Table 1). After the 1949 harvest season the machine was moved to the central packing house and operated as a stationary unit in grading an additional 4,100 bushels. At the close of the 1950 season it was moved to a loading dock and utilized in sorting 3,800 bushels that remained ungraded when the harvest was completed.

Fig. 1. Mobile orchard grader in operation. From left to right 1) Picker is emptying picking bucket onto moving feed belt; 2) Foreman is inspecting apples and controlling flow into eliminator section; 3) Woman is removing defective fruits from sorting belt; 4) Man is filling crates from end of sorting belt; 5) Worker who puts liners in empty crates and takes away filled crates. Note 1-horse-power gasoline engine mounted under sorting belt.

RESULTS

OPERATION OF EXPERIMENTAL GRADER

Labor requirements—It was found that to operate the experimental unit efficiently a grader crew consisting of a sorter, a filler, a crate-liner (when crates were lined) and a stacker were required. Such a team was able to sort from 56 to 61 bushels of fruit per hour.

One foreman supervised both the picking and grading crews and inspected the apples as they flowed over the receiving belt.

Procedure—When a picker had filled his bucket he walked to the machine, laid his bucket on the receiving belt, opened the canvas chute and allowed the fruit to flow out (Fig. 2). The foreman inspected the apples, and made sure that the fruit was not fed into the machine too rapidly. As the apples passed over the eliminator, under-sized fruit dropped through into a field crate. Defective apples were removed as the fruit passed over the sorting belt. The larger blemish-free apples then flowed into lined crates. The flow was controlled by the "filler" by means of a canvas chute, which enabled him to lower the apples into the crates with a minimum of bruising. The filled crates were leveled and removed by the "stacker" who also kept the "filler" supplied with empty crates.

When the trees adjacent to the grader had been picked, the machine was moved to the next "set". Two to three minutes were required to move from one set to another (Fig. 3).

Six or seven good pickers were needed to keep the machine supplied with apples when running at or near full capacity. It was easy for this crew to regulate their work so that they did not all arrive at the receiving belt at the same time.

Capacity—During the trial runs six or seven pickers and a sorting crew of four picked and sorted 7,852 bushels of apples in 135.25 working hours; their average output per hour was 57.9 bushels. During the test 586 bushels of undersized stock were eliminated and 463 bushels of defective fruit were sorted out (Table 1).

Costs—Each member of the grading crew was paid 75 cents per hour. The resulting labor cost was 5.35 cents per bushel.

It is assumed that the grading unit which cost approximately $500 will grade 100,000 bushels before it need be replaced. If this be true the per bushel cost of depreciation would be 0.5 cent.

The gasoline and oil required to operate the engine cost only 25 cents per day or 0.05 cent per bushel.

The total per bushel cost of sorting and packing, in unfaced crates, was 5.9 cents per bushel.

When the grader was operated as a stationary unit the average number of bushels sorted was increased to 70.8 per hour. Inasmuch as it was necessary to employ an additional man to dump the fruit, the

Table 1—Data on operation of the mobile orchard grader used in trials

Where sorted	Variety	Bushels sorted	Bushels large apples	Bushels small apples	Bushels defective apples	Bushels sorted per hour	Number in grading crew	Number in picking crew	Bushels per hour per picker
Orchard	McIntosh	3,861	3,325	274	262	56	4	6	9.33
Orchard	Delicious	1,942	1,710	151	81	61	4	7	8.73
Orchard	Jonathan	1,637	1,433	139	65	58	4	7	8.27
Orchard	Northern Spy	412	335	22	55	57	4	7	8.14
Totals and averages		7,852	6,803	586	463	57.9	4	6.51	8.90
Loading dock and packing house	Jonathan and Delicious	7,900	6,557	790	553	70.8	5		

total cost per bushel remained essentially the same (5.9 cents per bushel).

ADVANTAGES

As the work progressed it became apparent that under the conditions existing in many Michigan orchards, field grading is in some ways superior to methods now commonly employed. A brief discussion of the more important advantages follows:

Less handling—less bruising—After being picked, fruit that is handled in the conventional manner is placed in field crates. It is usually necessary to handle these crates several times before the fruit they contain is sorted, packed and stored, or sent to market. Handling the fruit in this way is not only hard work and time consuming, but results in bruising that is likely to increase in direct proportion to the amount of such handling.

Apples sorted on an orchard grader flow directly into the containers in which they move to market or cold storage. This means substantially less handling and a corresponding reduction in the amount of bruising.

Better handling—less bruising—In the conventional method of handling, considerable bruising occurs when the fruit is dumped into field crates. Unpublished data compiled by the authors, during a study of apple bruising, indicates that in dumping apples into field crates a careless picker may bruise up to 89 percent of the fruit when tender-skinned varieties such as McIntosh are being handled. The average number of bruises per apple may run as high as 3.7, and the average size of the individual bruise may be almost one-half inch in diameter. Additional mechanical injury takes place when the apples are poured from these crates onto the receiving belt of the grader.

The bruising studies already mentioned indicate that a careless job of dumping onto the grading line may result, on the average, in more than three bruises per apple. The average size of each individual bruise was almost one-half inch in diameter.

When a mobile orchard grader is used the fruit flows directly from the picking buckets onto the receiving belt with little or no damage (Fig. 2). This means that two steps, in each of which considerable bruising ordinarily occurs, are almost entirely eliminated.

Better supervision—less bruising—When a mobile orchard grader is used the foreman has an opportunity to inspect each half-bushel of

fruit as it flows onto the receiving belt. He has a direct check on the quality of the work done by each picker. The sorting and filling operations are also performed under the supervision of the foreman.

Fig. 2. Picker placing apples on receiving belt. Note that it is unnecessary for the picker to stoop and that the fruit does not drop but flows out of his picking bucket. Emptying the bucket in this way is easy and there is little if any damage to the apples.

Eliminates unnecessary handling of under-grade fruit—In the average Michigan planting, orchard-run fruit ordinarily contains from 15 to 40 percent defective and undersized stock. If the fruit is placed in cold storage, orchard run, the grower must pay cartage, storage, crate rental and liner charges for the under-grade fruit as well as on the number one stock. If the apples are run over a field grader, small and blemished fruits are eliminated in the orchard; and the grower does not have to pay the charges enumerated above on inferior stock.

When the price of under-grade fruit is low the savings effected in this way are considerable.

Increases picker output—In most orchards where conventional methods of picking are employed, it is necessary for the pickers to spend considerable time in carrying, arranging and lining empty crates. When the field grader was used the picker emptied his picking bucket directly onto the receiving belt. The time formerly spent in handling crates was now devoted to picking apples. In the cooperating orchard, pickers who formerly averaged 7 bushels per hour increased their output to 8.9 bushels when assigned to the mobile grader picking crew.

Reduces packing house space requirements—Fruit that is sorted in the orchard requires little or no packing house space. The use of one or more mobile graders makes it possible for the grower who handles a part of his crop in this way to get along with less space than would otherwise be required.

Increases storage life of apples—When tree-run stock is stored for any length of time, some of the bruised and damaged fruit is almost sure to develop rot that will spread to what would otherwise be fancy stock. Lou Bisno found that after three and one-half months of storage sound fruit developed 0.19 percent rot while bruised apples developed 40.00 percent rot (ratio of 200:1)[4]. When the apples are run over a field grader most of the fruits that would develop and spread rot are eliminated in the orchard.

Storage life depends to some extent upon how quickly the fruit is placed in refrigerated storage after harvest. The use of a field grader makes it possible to move the apples into cold storage almost immediately. This is not always possible when the fruit is moved to and graded in a central packing house.

Orchard graders can be used in several ways—As already pointed out, an orchard unit can be moved into the packing house, to a loading dock or any other convenient point and used as a stationary grader. Some growers may find it desirable to use the machine as a mobile unit for McIntosh, Northern Spy and other tender-skinned apples, and as a stationary grader in sorting less susceptible varieties that are picked in the conventional way and sorted during the evening or on a rainy day. The usefulness of a mobile unit does not end when harvest has

[4]"Stored Apples—Why They're Lost and How They're Saved," by Lou Bisno. Food Industries. Jan. 1950, p. 84.

been completed. During the winter months it can be moved to almost any point at which apples that need to be graded are being stored.

Increased net returns—Only a part of the apples produced in the cooperating orchard were sorted on the field grader. The rest of the crop was stored orchard-run and graded later. It was therefore possible to compare the cost of handling field sorted apples with that of comparable fruit handled in the conventional manner.

Of the 7,852 crates sorted in the field, 1,049 bushels of small and defective apples were eliminated and sent immediately to processing outlets. Had these apples been stored orchard-run the grower would have paid the following charges on each bushel:

Crate rental	10¢
Crate liner	5¢
Cartage	5¢
Storage	30¢
Total	50¢

The savings effected by eliminating the lot of 1,049 bushels amounted to $524.50. Because field-graded apples were not so badly

Fig. 3. Mobile field grader. Note pick-up truck in left foreground used to move grader. Moves can be made in two or three minutes. The stacked crates at extreme right are filled with apples that were sorted at the last "set."

bruised, this fruit when sold brought an average premium of 14 cents per bushel. This premium amounted to $952.42. When the savings effected on storage charges were added to the premium received for field-graded apples, the figures totalled $1476.92. This figure amounts to nearly 19 cents per bushel on all of the apples that were field graded.

LIMITATIONS

Orchard graders usually require auxiliary power—When mobile units are not equipped with wheels some sort of auxiliary power is needed to move the grader. However, most fruit growers have a tractor or truck that can be left with the unit throughout the day, or hooked on when moves become necessary. The manufacturers of graders that are equipped with wheels say that their units can be quickly moved by the crew without the use of auxiliary power.

For best results trees must be in double rows or blocks. If the number of grader "sets" is to be kept to a minimum and the pickers are to reach the machine with a minimum amount of walking, the trees of any one variety must be planted in double rows or blocks. When planted in this way, four to six and sometimes more trees are picked at one setting of the grader. If a particular variety is planted in a single row the number of sets must be increased or the pickers must walk farther.

Orchard graders are not practical in rough or hilly locations—In portions of some orchards the ground may be so rough or hilly that an orchard grader cannot readily be moved and operated. When sorting fruit that is grown in areas of this nature, the unit should be set up at the barn or loading dock and used as a stationary outfit.

The experimental model separated the fruit into only two size grades—The model used in the trials had only one eliminator section and was not equipped with a brusher. Because of these limitations, growers who wish to polish their apples, separate the fruit into several size and color grades and put up faced packages could not use such a unit to advantage. It is possible that subsequent models will enable growers to do a more complete job.

The use of a mobile grader makes it somewhat difficult to keep a piece-work record—If the individual pickers who work with a mobile grader are to be paid on the basis of piece-work, the count must be taken as the fruit is delivered to the machine. This means that the

foreman, or someone else to whom this task has been assigned, must be in constant attendance and devote a part of his or her time to keeping the record. Another possibility is to organize a crew that is willing to work as a unit. The total number of bushels picked by such a crew is recorded at the end of the run and each member of the team is credited with his proportionate share of the total amount of money earned.

The simplest and probably the best method of paying the orchard grader picking crew is by the hour.

CONCLUSIONS

The trials led to the conclusion that under the conditions existing in many Michigan orchards, a mobile grader will substantially increase net returns. It is most useful in orchards where the fruit is stored orchard-run and/or marketed in unfaced packages.

Three commercial concerns are already manufacturing mobile graders. The units being offered for sale are reasonably priced, the exact figure depending on the size and type of equipment that is included.

PRELIMINARY TESTS OF FUNGICIDE COMBINATIONS IN TOMATO SPRAYS AND DUSTS[1]

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THE PRINCIPAL fungous disease problems in the production of market or canning tomatoes are the three blights, early, late and Septoria blight which defoliate the plants, and anthracnose, the ripe fruit spot. Experience of several years has shown that applications of almost any of the fixed coppers at the proper time will control these blights, whereas Zerlate will control anthracnose. Consequently, our standard control recommendation has been an alternating schedule of sprays or dusts with a copper application put on the plants at one time and a week or 10 days later, a Zerlate application. This schedule is often confusing to growers and sometimes leaves too long a time interval between applications of copper or Zerlate for good disease control. Therefore, last season tests of several combinations of fixed copper and Zerlate, both as tank mix sprays and dust mixes, were undertaken.

The first step was to try mixing small batches of these fungicides in the laboratory to determine whether the materials were compatible. It was obvious that most of the fixed coppers, such as Cop-o-zinc, Tribasic Copper Sulfate, copper zinc chromate, or cuprous oxide at the usual concentrations could be combined with Zerlate at the rate of 2 pounds per 100 gallons in tap water. These mixtures did not break down when allowed to stand for several hours or several days. If soaps or wetting agents were added to the mixtures, however, a reaction between the fungicides took place, with the resulting production of copper carbamate. This reaction was accompanied by a color change from blue, green or red (depending on the original form of copper) to brown.

The next step was to determine what insecticides might be added without disturbing the equilibrium of the fungicide combinations. It was found that calcium arsenate, the old standby for flea beetles and hornworms, could be used, as well as Marlate, one of the newer mate-

[1]Contribution No. 51-4 from the Department of Botany and Plant Pathology, Michigan State College.
[2]The writer wishes to thank the Joseph Campbell Company which furnished the tomato plants for these tests, also the agricultural chemical companies which furnished materials and financial assistance, and the Michigan Fertilizer Company for mixing the dusts.

ARTICLE 33-42

Table 1—Summary of 1950 trials of fungicidal spray and dust mixes on tomato

Treatment	Formula	Total yield, tons per acre	Percentage of culls	Percentage defoliation Sept. 22
Control	untreated	7.7	27.0	95
Crag 658 * spray	2 lb.—100 gal.	10.2	18.0	50
Tribasic copper † spray	4 lb.—100 gal.	8.6	16.5	43
Cop-o-zinc † spray	4 lb.—100 gal.	8.0	15.5	40
Robertson copper ‡ spray	1.5 lb.— 100 gal.	8.0	17.5	47
Crag 658 and Zerlate § spray mix	2 lb., 2 lb.—100 gal.	10.2	10.5	42
Tribasic copper and Zerlate spray mix	4 lb., 2 lb —100 gal.	9.4	9.5	32
Cop-o-zinc and Zerlate spray mix	4 lb., 2 lb.—100 gal.	8.0	11.5	39
Robertson copper and Zerlate spray mix	1.5 lb., 2 lb.—100 gal.	9.0	11.0	42
Crag 658 dust	8%, talc 92%	10.6	22.0	66
Tribasic copper dust	13%, talc 87%	8.0	21.5	67
Cop-o-zinc dust	20%, talc 80%	9.3	22.5	74
Robertson copper dust	8%, talc 92%	8.0	23.0	60
Crag 658 and Zerlate dust mix	8%, 7%, talc 85%	12.5	16.5	62
Tr basic copper and Zerlate dust mix	13%, 7%, talc 80%	8.2	15.5	67
Cop-o-zinc and Zerlate dust mix	20%, 7%, talc 73%	8.6	16.0	66
Robertson copper and Zerlate dust mix	8%, 7%, talc 85%	8.3	18.0	65
Tribasic copper and sulfur dust mix	13%, 30%, talc 57%	8.6	22.0	71
Cop-o-zinc and sulfur dust mix	20%, 30%, talc 50%	9.2	23.0	72
L. S. D. (at 99 to 1)		n.s.	n.s.	7%

*Manufactured by Union Carbide and Carbon Corporation.
†Manufactured by Tennessee Corporation.
‡Manufactured by H. H. Robertson Company.
§Manufactured by E. I. DuPont and Company.

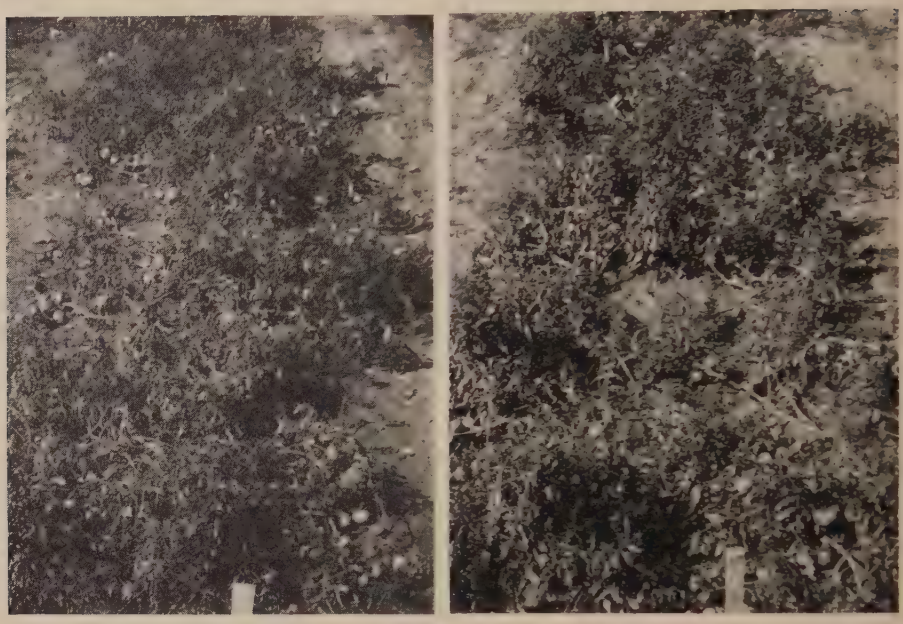

Fig. 1. Sample plots sprayed with fungicide combinations.
Left—Tribasic Copper Sulfate and Zerlate
Right—Crag 658 and Zerlate.
For comparison with untreated control plot, see Fig. 2.

rials. The addition of Rothane which contains a wetting agent resulted in the break-down of the fungicide mixtures.

The final step was to spray these mixtures on tomato plants to determine whether the dosage would be toxic to the plants and whether the diseases would be adequately controlled. Dust combinations of these various fungicides were mixed and tried at the same time. The fungicides tested are listed in Table 1.

METHODS

The tomato variety employed was Improved Garden State grown at Blissfield in cold frames. The methods of culture followed were the same as described for earlier spray tests.[3] Plants were set May 29 and 30th. There were 20 plants per plot replicated four times at random. Fungicide applications were made July 18, August 1, August 15, August 29, and September 12.

[3]Comparison of Fungicidal Sprays for the Control of Tomato Blights. Strong, M. C., Michigan Agr. Exp. Sta. *Quart. Bul 32:* 338-347 (1950).

Fig. 2. Sample plots dusted with fungicide combinations in comparison with untreated control.

Upper left—untreated control.

Upper right—Cop-o-zinc and Zerlate.

Lower left—Robertson copper and Zerlate.

Lower right—Tribasic Copper Sulfate and sulfur.

The season was cool and wet. Alternaria blight was present from the middle of July to the end of the season. No Septoria blight was observed. Anthracnose was abundant in September.

In mid-August tomato fruit and foliage infected with late blight were brought from southeastern Michigan and scattered through all the plots. However, the disease did not appear on the plants until September 21 following a rainy period accompanied by low temperatures. No plants in the sprayed plots were affected, but there was considerable fruit infection in the untreated and dusted plots.

Ripe fruit was picked, graded and weighed at 7-day intervals or less, beginning August 29 and continuing until the end of September. Killing frost occurred October 3. Yield data, as well as percentage of culls produced, are recorded in Table 1. Yield data represent totals of six pickings computed on the basis of tons per acre while the percentage of culls is the actual percentage for the six pickings. Culls include fruit damaged by anthracnose, sunscald, Alternaria, and Phytophthora rot.

Defoliation counts were made at regular intervals, the figures in Table 1 being those obtained on September 22. The method used was as described by Horsfall and Barrett.[4] Twenty plants from each treatment were graded into 12 ranks of defoliation and the average grade determined. This number was then converted to a percentage basis, and was recorded in Table 1.

DISCUSSION OF RESULTS

The results obtained in these tests are summarized in Table 1. Four fixed copper fungicides are compared alone in sprays and dusts and with the addition of Zerlate in tank and dust mixes as well as with untreated control plots.

None of the spray or dust combinations tested exhibited any toxic effects on the plants. None of the tank mixes broke down during application nor later on the plants. No apparent interaction of chemicals took place in the dusts during the period of application from mid-July to mid-September, but at the present writing some of the dust combinations in storage have turned brown, indicating that a reaction has taken place.

[4]An Improved Grading System for Measuring Plant Diseases. Horsfall, J. G. and R. W. Barrett, Phytopath. 35: 655 (1945).

For blight control, the sprays were more effective than the corresponding dusts, as is shown by a comparison of Figs. 1 and 2 as well as by the percentages of defoliation recorded in Table 1. The addition of Zerlate to the copper treatments increased effectiveness against anthracnose. The addition of sulfur did not control anthracnose and had a tendency to intensify sunburn on fruit.

Yields were relatively low, owing in part to wet weather in September and to a rather short picking season (4 weeks). Statistical analysis of these data revealed that differences in yield and percentage of culls are not significant. Differences among replications were sometimes as great as among treatments. This was the result of wet weather during harvest when there was a considerable loss of fruit on certain plots where water stood for about a week. Rain occurred daily from September 10 to 14 inclusive, totaling 2.64 inches for the 5-day period.[5]

Defoliation of plants is an index of the severity of the leaf blights and thus indirectly an index of the fungicidal value of a protective treatment. The greater the percentage of defoliation, the less is the fungicidal value of a particular treatment. All treatments reduced the percentage of defoliation much below that recorded for the untreated plots. Some treatments were better than others in preventing defoliation. Statistical analysis showed that the least significant difference in percentage of defoliation is 7 percent (see Table 1).

CONCLUSIONS

No definite conclusions can be drawn from a single season's tests and these combinations of fungicides are not recommended for grower's use at this time. However, results are promising enough to warrant continuation of these experiments. If successful, the fungicide combinations will offer the tomato grower better disease control for the same or perhaps less expenditure of effort.

[5]U. S. Department of Commerce Climatological Data for Michigan. September 1950, Vol. LXV, No. 9.

CONTROL OF MOSSY STONECROP (*SEDUM ACRE* L.) AND CERTAIN OTHER LAWN WEEDS

By BUFORD H. GRIGSBY
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THE EASE with which dandelion and buckhorn can be controlled in turf by the use of 2,4-D sprays has resulted in considerable interest in methods for the control of other turf weeds. A number of weeds, however, do not respond to the usual spray treatments. These resistant forms become very conspicuous in a sprayed lawn and are a source of annoyance to home owners, park superintendents, and others concerned with turf maintenance. The large number of inquiries received from these persons led to some investigations of chemicals and methods of application.

SEDUM ACRE L.

Mossy stonecrop, usually because of escape from flower garden plantings, has become a rather common weed in turf. The plant is a small, smooth, thick-leaved perennial herb which occurs in moss-like spreading clumps. The leaves are yellow-green and are closely overlapped on the short stem. Small yellow flowers are borne on the upper part of the stem. Spreading is accomplished by means of seeds and by the rooting of small fragments of the stem. Because of this vegetative propagation, mowing tends to spread the infestation quite rapidly.

Numerous inquiries by home owners indicate that mossy stonecrop is not controlled by applications of 2,4-D at the usual dosage. To determine an effective control measure, a number of common herbicides, and some new materials were applied to lawn plots heavily infested with the plant. Applications were made early in July 1950, and final results were obtained in the latter part of August. The chemicals used, rates of application and results are shown in Table 1.

[1]In cooperation with the Division of Weed Investigations, Bureau of Plant Industry, Soils and Agricultural Engineering, U.S.D.A.
[2]Contribution 51-3, Department of Botany and Plant Pathology.

ARTICLE 33-43

Table 1—Effects of herbicides on Sedum and turf

Herbicide	Rate in ounces per 1000 sq. ft.*	Effects 5 weeks after spraying	
		Sedum, percent killed	Turf
2, 4, 5-T amine	0.75	10	No visible effects
2, 4, 5-T ester	0.75	100	No visible effects
2, 4-D amine	0.75	0	No visible effects
2, 4-D ester	0.75	95	No visible effects
Polyethelyne carbonate	0.75	0	No visible effects
Xanthogen disulfide	3.75	0	Annual grasses killed, perennial grass injured
Endoxohexa hydrophthallate	1.50	0	All grass burned to ground
Stoddard solvent	235.00	0	Annual grasses killed, perennial burned but recovering
Stoddard solvent, fortified	235.00	0	Annual grasses killed, perennials severely injured
Crabgrass spray oil and 2, 4-D ester	235.00 0.37	100	Annual grasses killed, blue grass unaffected
Phenyl mercuric acetate	3.50	0	Grasses yellow and stunted

*All rates are expressed in ounces of actual effective ingredient.
The chemicals were applied in 1 gallon of water, or oil, per 1000 sq. ft.

Two weeks after spraying it was apparent that the amine formulations of 2,4-D and 2,4,5-T were entirely ineffective. Ester formulations, however, were causing the death of this plant. *Sedum* sprayed with either ester became light yellow, the leaves were loosened and fell from the stem when the plants were disturbd, as by passing a hand or foot over the clumps. The stems became dry, brittle and failed to form new roots. The old roots also became dry and obviously dead. No regrowth appeared in the ester-treated plots during the remainder of the season.

In the experimental area there was a rather heavy infestation of yellow foxtail, and it was observed that when the ester of 2,4-D was applied in a petroleum product which is used to control crabgrass a complete elimination of both *Sedum* and foxtail followed the treatment. Crabgrass was not present in this lawn.

None of the other chemicals, at the rates used, had any lasting effects on *Sedum*. Xanthogen disulfide and endoxohexahydrophthallate caused a browning of the leaves, but regrowth took place in a short time. Injury to turf grasses was greater than that to the *Sedum*. The other compounds had no effect on *Sedum* and caused considerable injury to turf grasses.

Experimental sprayings, in the past two or three seasons, have given indications of methods of application which will kill a number of other lawn weeds. These observations are presented for use in cases where only small patches of weeds are a problem, and in most instances they should be considered as emergency methods.

POLYGONUM ANICULARE L.—DOORYARD KNOTWEED

Knotweed often becomes a pest in lawns, especially along the edges of sidewalks and other areas where foot traffic is heavy, or where soil conditions are not favorable for the growth of grass. This weed also invades playground areas in parks and athletic fields.

Control of knotweed usually is not obtained with water sprays of 2,4-D. Such applications may be successful, however, if made when the weed is in a very early stage of growth. In most instances, this susceptible stage is missed and poor results are obtained.

Trials at East Lansing have shown that control of the weed can be obtained by applying the ester form of 2,4-D in an oil carrier. The oil used must be relatively non-toxic to vegetation and is used in order to secure penetration of the tough, waxy leaves of knotweed. A water white grade of kerosene may be used as a carrier, but best results have been obtained by combining the 2,4-D with a special oil fraction sold as Crabgrass Spray Oil. A satisfactory rate of application is ½ ounce of 2,4-D, acid equivalent, in 1 gallon of oil per 1000 square feet. This treatment has not caused any injury to lawn grasses in our trials and can be made at any season when the weed is growing.

In September 1950, an application of endoxohexahydrophthallate, at the rate of ½ ounce per 1000 square feet, was made on knotweed and a complete kill was obtained. This treatment, however, caused a severe burn of Kentucky blue grass, and Chewings fescue. Alta fescue was not injured by the treatment, and the Kentucky blue grass eventually recovered.

STELLARIA MEDIA (L.) CYRILL., COMMON CHICKWEED, AND CERASTIUM VULGATUM L., MOUSE-EAR CHICKWEED

Both of these species of chickweed are of common occurrence and both are resistant to the amine and sodium salt formulations of 2,4-D which are ordinarily used for turf weed control. Many trade-name preparations of these compounds indicate that chickweed is controlled

by the compound; however, experience has shown that often this is not the case.

In an effort to determine suitable control measures for chickweeds the following chemicals have been tried at rates known to be effective on many other weeds:

2,4,5-T in water
2,4-D, ester in water
2,4-D, ester in non-toxic oil
Stoddard solvent, undiluted
Dinitrophenol, selective grade, in water (DN)
Sodium pentachlorophenate, in water (PCP)
Sodium trichloroacetate, in water (TCA)
Endoxohexahydrophthallate, in water
Lead arsenate, dry powder
Isopropyl phenyl carbamate, dry powder (IPC)
Maleic hydrazide, in water

Water sprays of 2,4-D, 2,4,5-T, maleic hydrazide and TCA were ineffective on both weed species. Endoxohexahydrophthallate caused defoliation of common chickweed but had no effect on the mouse-ear type.

The oil solution of 2,4-D ester, at 2 pounds per acre, and 15 pounds of IPC each gave a satisfactory kill of chickweed when applications were made in the fall. At that time new seedlings were appearing and these were sensitive to the action of the two chemicals.

Stoddard solvent, at the rate of 1 gallon per 1000 square feet killed chickweeds in early spring and late fall treatments. Perennial grasses were killed to the ground line, however. Recovery of grasses occurred in 5-10 days following the treatment.

Dinitrophenol, at the rate of ¾ ounce per 1000 square feet, and pentochlorophenol at the rate of 6½ ounces per 1000 square feet were equally effective in killing chickweed. The mouse-ear form seemed to be a little more difficult to kill, but when a wetting agent was added to the solution both species were killed. Both forms of phenolic herbicides caused some injury to turf grasses, either a yellowing of leaf tips or the formation of small white spots on the leaves. These injuries were of a temporary nature, however, and recovery was rapid.

Applications of arsenate of lead at 5 ounces per 1000 square feet and endoxohexahydrophthallate at the rate of ½ ounce had no effect

on chickweed. The latter compound caused considerable injury to lawn grasses.

MISCELLANEOUS WEEDS

Black medic, *Medicago lupulina L.*, usually is not killed by any form of 2,4-D and did not respond to the oil carrier applications used in these experiments. Complete eradication of this weed legume was accomplished by use of the endoxohexahydrophthallate treatment.

Sand bur, *Cenchrus pauciflorus* Benth., was killed by the application of Stoddard solvent as described for chickweed. The treatment was applied when the weed was 4-6 inches tall but before it had produced young burs.

Mallow, *Malva rotundifolia* L., and yarrow, *Achillea millefolium* L., were not killed by any treatment used in these trials. Considerable injury to these weeds was caused by the oil—2,4-D treatments but regrowth occurred shortly after the treatment.

DISCUSSION

The results obtained with the ester of 2,4-D on mossystone crop indicate that control of this weed can be obtained on a selective basis, that is, without injury to turf grasses. The method suggested will also destroy dandelion, buckhorn and any other broad-leaved weeds which are susceptible to the action of 2,4-D. The chief objection to the use of this method of control is that vapors from the sprayed areas may cause some injury to ornamental plantings. Because of this fact, it is suggested that the spray be applied as early in the spring as growth of the stonecrop will permit. A careful examination of shrubs and herbaceous plants adjacent to the areas sprayed in 1950 did not reveal a single case of 2,4-D injury, but the fact that a certain amount of risk is always present should be recognized by all who use the method.

The methods suggested for chickweed, knotweed and the other species mentioned, are generally not entirely selective and may cause some injury to grasses. These methods, therefore, are considered as emergency treatments to be used when the weeds become a serious problem. Generally these will be treatments applied on small patches of turf, and the injury, resulting from the treatment of small areas is of less consequence than the benefit derived from the destruction of the weeds. Any injury from the treatments used in these experiments is of a temporary nature and recovery of grasses will follow.

The weeds used in these experiments are almost always found in turf where the growth of grass is not satisfactory, for one reason or another. In such areas, removal of the weeds is only a partial solution and after the weeds are destroyed it is necessary to secure adequate growth of vigorous grasses. This can be done by correcting poor soil conditions, fertilizing, seeding and watering. The rapid introduction of desirable grasses is essential in order to prevent reinfestation of areas in which weeds have been killed.

SUMMARY

The results from applications of various herbicidal sprays on a number of turf weeds, which usually are not killed by the ordinary lawn spray treatment, are presented. Based on these results, the following treatments for weeds are suggested:

1. 2,4-D ester in water at the rate of ¾ ounce per 1000 square feet on mossy stonecrop.
2. 2,4-D ester in non-toxic oil, ¾ ounce per 1000 square feet on knotweed, chickweeds and mossy stonecrop.
3. Stoddard solvent, 1 gallon per 1000 square feet on chickweeds, sand bur, annual grasses.
4. Dinitrophenol, ¾ ounce per 1000 square feet or pentochlorophenol, 6½ ounces per 1000 square feet on chickweed.
5. Endoxohexahydrophthallate, ½ ounce per 1000 square feet on black medic.

Reseeding, fertilization and proper watering should follow all the suggested herbicidal treatments.

FIELD EXPERIMENTS ON THE CONTROL OF POTATO LATE BLIGHT[1]

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DEPARTMENT OF BOTANY AND PLANT PATHOLOGY

FOR SEVERAL years field tests of the effectiveness of various fungicides in disease control have been carried on in Michigan, but during most seasons, late blight of potato has been absent or has occurred in only negligible amounts. During the season of 1950, weather conditions, with warm days and cool nights accompanied by frequent rains or heavy dews, were ideal for development of the potato late blight fungus in many areas of the state.

Field experiments were carried on at the Lake City Experiment Station and on individual potato growers' fields in four counties of the upper peninsula and two in the lower peninsula.

LAKE CITY EXPERIMENT STATION TESTS

At the Lake City Experiment Station, tests were made of 12 fungicides. The sprayed plots consisted of four rows, 100 feet long, randomized for materials and replicated four times. The plots were laid out so that an unsprayed plot was adjacent to each sprayed plot. The plots were planted to the Chippewa variety May 22 and harvested September 20. Supplemental water was applied by means of an overhead rotary sprinkler irrigation system which delivered approximately 1 acre-inch of water per hour.

Application of fungicides was made with a tractor-drawn, engine-powered, four-row sprayer at a pressure of 350 pounds. The first four applications were made at 10-day intervals on June 29, July 11, 21, and August 1. The last five applications were made at weekly intervals on August 9, 15, 23, 31, and September 7, owing to rapid growth of

[1]Contribution 51-5, Department of Botany and Plant Pathology, Michigan State College.

[2]The writers are indebted to Mr. A. M. Beveridge, Superintendent of the Lake City Experiment Station for assistance in these tests, also the county agricultural agents and potato growers for aid in the county spray and dust materials trials, and to the cooperating manufacturers of agricultural chemicals for materials and for other assistance furnished.

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vines and weather conditions favoring late blight development. DDT at the rate of one pound in 100 gallons of spray material was applied in each application. An additional application of parathion, 1 pound in 100 gallons of water was made August 16 for aphid control.

Vines in row 3 of each plot were killed by a rotary vine beater on September 12 to facilitate harvesting and to prevent further infection of tubers from late blight. Records of yield and percentage of tuber infection were taken from this row.

Weather conditions during the season were relatively favorable for growth and for development of potato late blight. The average temperature during June was 64.1° F. with total precipitation of 2.37 inches. During July the average temperature was 64.5° F. and the total precipitation of 3.2 inches fell in 10 days, principally after July 13. For the month of August, the average temperature was 62.3° F. and total precipitation 3.45 inches. No rain fell from August 3 to 15, but from August 25 to 31 there were 2.34 inches of rain. There were 18 nights in August when temperatures varied between 34° and 50° F. September was relatively cool, with precipitation of 1.95 inches up to time of harvest.

Late blight was first seen on a few scattered plants in the unsprayed plots on August 13, but made little headway until the week of August 25 when both temperature and rainfall made ideal conditions for development of the disease. Attempts were made to apply sprays immediately before rainfall or periods of irrigation.

Results of the spray tests are given in Table 1.

The check plots, receiving only DDT at each application, showed an average of 23.75 bushels per acre of tubers affected with late blight, with only a minimum amount (0.25 bushel to none) for the sprayed plots. Total yields were significantly greater than those of the check plots, but the yields of U. S. No. 1 tubers were not significantly greater. On the plots where the spray materials included the fixed coppers, Tribasic Copper Sulfate, and Cop-o-zinc, Thiodow (a carbamate) and the two experimental organic compounds 1124 and 1189, there were appreciable increases in yield. It is of interest to note that although the total yield from the Dithane D-14 plot was not statistically significantly greater than that for the controls, the yield of U. S. No. 1 tubers ranked fifth. There were no marked differences among materials in late blight control.

Table 1—Results of spray materials tests, Lake City Experiment Station

Material and dosage	Yield in bushels per acre	
	U.S. No. 1	Total
1. Tribasic 4-100	369.1	450.1*
2. Gen. Chem. 1124 4-100	347.3	453.7*
3. Dithane D-14 2 qt.—1 lb. zinc	346.1	406.5
4. Gen. Chem. A 4-100	301.3	423.5
5. Crag 658 2-100	312.2	438.0
6. Gen. Chem. 1189 4-100	393.3	492.5*
7. Parzate 2-100	334.0	430.7
8. Gen. Chem. B 4-100	331.5	413.8
9. Bordeaux 8-4-100	317.0	388.4
10. Gen. Chem. C 4-100	265.0	379.9
11. Cop-o-zinc 4-100	325.5	454.9*
12. Thiodow 2 qt.—1 lb. zinc	381.2	493.6*
13. Check—DDT only	297.7	389.5

*L.S.D.=59.2 bushels per acre at 5 percent level.

FUNGICIDE TESTS ON POTATO FARMS

Certain spray materials previously tested at the Lake City Experiment Station were given further field trials on one potato farm in each of the following counties: Delta, Houghton, Luce, Menominee, and Kalkaska. In each of these tests, single or duplicated one-acre blocks of potatoes were sprayed with the test materials in comparison with the fungicide used by the grower in late blight control.

Late blight in most tests was not found or it occurred in only negligible amounts. No loss from tuber rot was reported from any of the tests.

Results of these tests are given in Table 2. In Houghton County, plots receiving applications of Copper A plus zinc sulfate and Dithane D-14 were outstanding in yields. The new material Crag 658 gave somewhat smaller yields than the other materials in Delta, Kalkaska

and Luce Counties. In Kalkaska County, bordeaux mixture showed highest yield of the four materials used. In general, yield differences among materials were not consistent in the various county plots, but all materials gave satisfactory control of late blight.

Table 2—Results of county spray tests

Spray material	Yield in bushels per acre				
	Delta County	Houghton County	Kalkaska County	Luce County	Menominee County
Bordeaux	.....	.....	261.0	180.9	.....
Crag	480.9	.....	227.0	157.6	.....
Cop-o-zinc	508.2	279.6	247.0	199.4	495.7
Tribasic	.....	284.6	240.0	171.0	520.7
Dithane D-14	508.2	312.4	.....	216.4	.....
Copper A	.....	274.9	.....	.....	.....
Copper A + Zinc	.....	347.1	.....	.....	.....

Dust materials tests were made on the James McLeod muck farm in Eaton County. The one-acre plots comprised 12 rows of the variety Chippewa. Dusts were applied with a six-row machine driven by a power take-off. An average of 50 pounds of dust were used in each of eight applications.

Late blight was first seen in the plots on August 19 when only a few plants showed a trace of leaf infection. At this time, however, other potato fields in the vicinity showed considerably more late blight. Weather conditions in July and August were very favorable for development and spread of the causal fungus. Warm days with cool nights and frequent rains in August caused infection to develop rapidly, so that by September 9 practically every plant in all the plots showed abundant sporulation of the late blight fungus on either leaves or stems. Intermittent rains and heavy dews in September made dusting operations difficult and also favored continued development of the late blight disease. Since the crop at this time was not ready for harvest, dust materials were applied at shorter intervals to prevent further spread of infection to new foliage and prevent the fungus spores from washing into the soil and infecting the tubers. Dusting continued through September 20 and the vines were killed with a rotary vine beater early in October. In beating the vines, the old potato tops were thrown between the potato rows to prevent washing of spores

of the late blight fungus into the potato hill. Results of these tests are given in Table 3.

Table 3—Results of county dust tests

Dust material	Yield in bushels per acre			Late blight tuber rot per acre, in bushels of infected tubers
	U.S. No. 1	U.S. No. 2	Total	
Z-78	386.8	145.2	532.0	5.6
Crag 658	400.8	162.0	562.4	5.4
Cop-o-zinc	413.1	187.3	600.4	7.4
Gen. Chem. #1189	370.5	176.7	547.2	15.4

The results of these tests show that with the exception of experimental compound number 1189 (a thiocyanate) all materials offered good control of late blight under conditions of heavy infection. The data also indicate that Cop-o-zinc gave somewhat better total yields and yields of U. S. No. 1 potatoes than the other materials although differences among results obtained were not highly significant. In this test the thorough and timely applications of dust fungicides were no doubt of greater importance than the material applied in control of potato late blight. In nearby fields where an adequate control program was not practiced, the crop was heavily damaged by late blight.

SUMMARY AND CONCLUSIONS

Results of the tests of various potato fungicides show that thorough and timely applications are all-important in control of the late blight disease.

In the spraying tests, yield data show that the carbamates (Thiodow and Dithane D-14) along with the fixed coppers (Cop-o-zinc, Tribasic Copper Sulfate, Crag 658, and Copper A) have an important place in potato late blight control. The two experimental compounds, 1189 and 1124, when used as sprays controlled late blight and gave yields ranking among the first four both in total yield and yield of U. S. No. 1 potatoes. Bordeaux mixture gave good control of late blight also, but in the Lake City Experiment Station trials it resulted in lower yields. Yield effects of bordeaux varied in Luce and Kalkaska Counties.

In the dusting experiments the fixed coppers permitted higher yields than did the carbamate, Z-78 or the experimental compound 1189, a thiocyanate.

LIME, PHOSPHATE AND POTASH FOR ALFALFA IN THE UPPER PENINSULA OF MICHIGAN

By A. R. WOLCOTT and WM. CARGO[1]

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SEVENTY-EIGHT percent of the alfalfa acreage in the upper peninsula in 1944 was in three southern-tier counties, namely, Delta, Dickinson and Menominee. This is predominantly an area of well-drained, high-lime soils of the Onaway and Trenary soil types, generally ideal for alfalfa.

Farmers in this area have experienced increasing difficulty in securing and maintaining good stands, owing to winter-killing and to nutritional deficiencies as indicated by leaf yellowing. They have been led by reports in recent popular farm literature, based upon experimental results in other states, to suspect a deficiency of boron (1, 2, 3, 8).

A series of experiments was started in this area in 1947 to investigate the possibility of minor element deficiencies on alfalfa. Boron, sulfur and manganese have been tried. Responses to date have given no reason to suspect a general deficiency of any of the three in these soils at the present level of alfalfa yields in the area.

Lime, phosphate, and potash applications were included in these experiments. The response of the alfalfa crop to these treatments has been large enough to warrant a preliminary report of this phase of the investigation at the present time.

FIELD EXPERIMENTS

Four experiments were conducted on Onaway loam and fine sandy loam soils in Dickinson and Menominee Counties and one on Hiawatha fine sandy loam in Iron County. This last field is not in the area of high-lime soils. It was selected because the second growth following the first cutting on a new seeding contained large, irregular patches

[1]Acknowledgment is made to the following County Agricultural Agents for invaluable assistance in carrying on the reported studies:
G. E. Bowers—Menominee County.
F. J. Molinare—Dickinson County.
A. W. Otterbein—Iron County.
Acknowledgment is also made to the farmers listed in Table 1 for their interest and whole-hearted cooperation in establishing and harvesting the experimental plots.

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in which alfalfa was stunted and showed various symptoms of nutritional deficiency.

All fields (Table 1) were in a grain-hay rotation, except at Kaski's. Here a crop of potatoes, heavily fertilized, was removed in 1947 before the field was limed and seeded to alfalfa in oats, in 1948.

The soil reaction at the Kline farm was pH 5.5, and at Kaski's it ranged from 5.5 to 6.0. At the other three locations it was at or near neutral[2].

No fertilizer was used with the seeding at Rostagno's but 400 pounds per acre of 0-20-0 was topdressed in early spring of the first cutting year. All other fields received 250 to 500 pounds of complete fertilizer with the grain at seeding time.

On the Kline farm, the fertilizer treatments on the alfalfa were broadcast in midsummer after the first cutting of hay on an unthrifty,

Table 1—Effect of topdressing with phosphate and varying rates of potash on yields of alfalfa in the upper peninsula

Location, soil type and pH	Date fertilizer applied	Cutting	Date	Treatments and yields*					LSD†
				None	0-20-0	0-20-10	0-20-20	0-10-30	
				Lb./A	Lb./A	Lb./A	Lb./A	Lb./A	Lb./A
Lamiel Kline farm Menominee County Onaway fine sandy loam, pH 5.5	Aug. 1947.. ‡	1st	July 1948	1,225	1,424	1,723	2,749	.....	744
Geo. Damme farm Menominee County Onaway loam, pH 6.5	Sept. 1948.. §	1st	June 1949	2,875	.....	.....	4,327	.....	Not sig.
Allen Corey farm Menominee County Onaway fine sandy loam, pH 7.0	Sept. 1948.. ¶	2nd	Aug. 1949	2,154	.....	2,776	2,876	.....	289
		1st	June 1950	2,368	.....	2,693	2,831	.....	67
Cecil Rostagno farm Dickinson County Onaway loam, pH 7.0	May 1950.. §	1st	June 1950	2,924	3,088	.....	3,822	4,411	645
		2nd	Aug. 1950	1,635	1,550	.....	2,053	1,994	Not sig.
Eino Kaski farm Iron County Hiawatha fine sandy loam, pH 5.5 to 6.0	May 1950.. §	1st	July 1950	2,733	3,480	.....	3,763	4,031	645

*Yields are in pounds per acre dry hay. Treatments were at the rate of 400 pounds per acre, except at Kline and Damme farms where 300 pounds rate was used.
†LSD—Least significant difference.
‡3 plots of each treatment.
§2 plots of each treatment.
¶4 plots of each treatment.

[2]Note: "pH"—a measure of soil acidity. A pH of 7.0 is neutral, any figure below that indicates an acid, or "sour soil." Alfalfa requires a pH of 6.5 to 7.0 (9).

two-year-old stand. On the Kaski and Rostagno farms the treatments were broadcast in early spring of the second year of the stands. One plot on an old established stand at Damme's was topdressed in early fall, the other early the following spring. At Corey's, fertilizers were spread in fall of the seeding year following removal of the oats nurse crop.

No record of yields was obtained of the first cutting after fertilization at Corey's owing to unfavorable weather at haying time.

The yields from the variable potash plots in these experiments are given in Table 1.

RESULTS

Soil reaction tests indicated that soil acidity was primarily responsible for the unthriftiness of the alfalfa on Kline's and Kaski's fields. Attempts to correct the soil acidity on the Kline's field by broadcast applications of *hydrated lime* were not satisfactory. The topdressing of *hydrated* lime, combined with the heavier rate of potash fertilization, resulted in definite injury to the stand and subsequent yields.

Lime had been applied at Kaski's during the fall before the seeding was made in the spring of 1948. The variability and the acidity of the soil, as shown by soil tests in 1949, indicated that the lime had not been worked into the soil uniformly, and that it had not been applied far enough in advance of seeding to have full effect in counteracting the soil acidity. Also, a heavier application undoubtedly should have been made. The alfalfa was largely replaced in the spring of 1950 by volunteer alsike clover. The increases in yield following fertilizer treatments represent the response of alsike, which is more tolerant than alfalfa to soil acidity.

The stands of alfalfa were good on the fields having a soil reaction above pH 6.5.

The greatest increases in yield in every instance, as shown by the data in Table 1, were in response to the higher rates of potash fertilization.

Response to phosphate alone was unsatisfactory at all locations. This should not be interpreted to mean that phosphate is not necessary. Soil tests for phosphate are almost always very low on these soils. Chapman (4) reports that, in the past, phosphate has been the number one deficiency in soils of the corresponding northern areas of Wisconsin. More recently the number one spot has been taken over by

potash. In the Wisconsin studies, as well as in experimental work by Grantham and Millar (7) and by Cook and Millar (5) on a variety of soils in Michigan, the importance of using phosphate and potash together on legumes in general, and alfalfa in particular, has been very well demonstrated.

The data in Table 1 show that the benefits from fertilization of the alfalfa were not limited to the first cutting. Second-cutting yields and yields the second year after fertilization were also increased.

Observations at the Allen Corey farm indicate that better winter-survival and improved plant vigor were both factors in maintaining yields the second year after phosphate and potash fertilization.

Observations and plant tissue tests at those locations indicate that border-line potash deficiency may express itself as a yellowing of the leaves before the typical white spots of potash deficiency appear. Leaf yellowing, however, is not a specific symptom. It may result from a number of causes, as leaf-hopper damage, poor drainage, poor soil aeration, lack of lime, deficiency of boron, manganese, or other minor elements. Only the scattered white dots on the leaves are specific leaf symptoms of potash hunger (6).

Response of alfalfa to boron, manganese, and sulfur (not reported here) have been erratic and not significant statistically. Results have been influenced by varying moisture conditions in different years. The possibility has not been ruled out that deficiencies of boron and other minor elements may develop later. Such deficiencies may show up when the general level of alfalfa yields in the area is increased as a result of the primary needs of alfalfa for lime, phosphate and potash being more adequately met. An increased interest in soil testing, which has resulted in the establishment of soil testing laboratories in the area, will undoubtedly hasten this development.

Studies are being continued to establish more definitely the role of the minor elements in a stepped-up fertilization program in these grain-hay rotations.

DISCUSSION

Northern soils, in general, were developed under a forest cover and are highly leached. This is particularly true of potash on high-lime soils, because lime tends to release potash and hasten its removal in drainage water.

The low original supplies of potash in the highly leached soils of the upper peninsula have been depleted still further by cropping, leaching from fall plowing and summer fallows left open through the winter, and by heavy losses from improper management of livestock manures. The soils which were used in the present study are typical in this respect.

In the area where the experiments were conducted, dairying is the major farm enterprise. Potatoes are an important cash crop, but they occupy a minor acreage—3 to 4 percent of the cropland. The typical rotation includes one or two years of grain, followed by two or three years of alfalfa-brome or a mixture of alfalfa with other legumes and grasses. In Menominee County, and to a lesser extent in other parts of the area, corn is substituted for all or part of the acreage in first-year grain. To avoid delaying the maturity of the grain, a fertilizer relatively low in potash must be used with the hay seedings (9). This does not supply enough potash to carry the alfalfa through the rest of the rotation.

Occasionally, a dairy farmer reports having used light annual applications of manure on alfalfa fields with good results in increased yields and longevity of stands. Some potato growers in the area use sufficiently heavy applications of high potash fertilizer on potatoes (800 to 1000 pounds per acre or more) to meet adequately the potash needs of alfalfa in their rotations. Experimental results at Chatham reported by Tyson (9) indicate that on such rotations, topdressings of phosphate alone on alfalfa may be sufficient.

The experimental results reported here, however, indicate that generally potash is the first limiting factor in alfalfa yields in this area. The yield increases shown in Table 1 demonstrate that rotational requirements for potash in a grain-hay farming program can be met and longevity and yields of alfalfa can be profitably improved by topdressings of phosphate and potash together on established stands. The most profitable increases may be expected from fertilizers high in potash, as 0-20-20 and 0-10-30.

The fact is brought out that some soils in this high-lime belt of the peninsula are too strongly acid for best growth of alfalfa. Soils should be tested periodically for their lime requirement. If soils become more acid than pH 6.5, additional lime is needed for alfalfa. When needed it is advisable to apply lime at least 6 months before the alfalfa is seeded, and it should be worked thoroughly into the soil.

CONCLUSIONS

1. Potash seems to be the first limiting factor in alfalfa yields and in the maintenance of alfalfa stands on the high-lime soils of the major alfalfa-producing area of the upper peninsula at present.

2. Alfalfa yields can be profitably increased by topdressings of fertilizers containing both phosphate and potash on established stands.

3. Up to the present time, no general deficiency of boron or other minor elements is indicated by experimental studies on these soils. As alfalfa yields are increased in response to more adequate fertilization, minor element deficiencies may develop.

4. Lime is deficient for alfalfa on individual soils and fields scattered throughout the area of high-lime soils. Soils should be tested periodically.

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BROMEGRASS AS AN EFFECTIVE AGENT IN QUACKGRASS CONTROL

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Quackgrass *(Agropyron repens)* is the predominant grass species in hay and cultivated pasture stands 2 years old or older in most areas of the upper peninsula. It is an aggressive perennial grass. It spreads rapidly in rotation fields, both from seed and by the vigorous growth of underground rootstocks. In hay and pasture mixtures it quickly replaces the original species as they die out.

It is generally conceded that quackgrass makes good quality hay when cut early (4, p. 435). Churchill (2) and Dexter and Clanahan (3) have shown that yields and quality of quackgrass hay in the upper peninsula can be profitably improved by early spring applications of nitrogen followed by early cutting.

For pasture or for hay, however, quackgrass cannot equal the performance of the more productive cultivated grasses under similar fertilization and management. In the work reported by Dexter and Clanahan (3), the three-year average dry hay yields for unfertilized quackgrass were 1,660 pounds per acre for early cutting and 2,249 pounds per acre for late cutting. The application of 40 pounds per acre of nitrogen increased yields to 3,144 pounds for the early cutting and 3,310 pounds for the late cutting. Timothy yields reported by Tyson (7) for a two-year period averaged 2,278 pounds per acre for unfertilized plots and 5,518 pounds for plots that received 40 pounds per acre of nitrogen. The timothy was cut at a time intermediate between the times of the two cuttings of quackgrass in the other study. Ahlgren and Burcalow (1) found bromegrass to be one-fourth more productive than timothy in mixtures with alfalfa. Bromegrass surpasses both quackgrass and timothy in total protein and digestibility of nutrients, as well as in the ability to retain nutritive value and palatibility at more mature stages of growth (4, pp. 423, 1086-1098).

The cost of summer fallow tillage to control quackgrass for grain in hay and grain rotations is extremely high in relation to the acre value of the grain crop. Where quackgrass is inadequately controlled, grain

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yields are severely reduced. A moderate infestation of quackgrass reduced oat yields 30 percent at Chatham (9). The rapid recovery of quackgrass in hay and pasture plantings makes it necessary to summer fallow for grain every time the grain appears in the rotation.

It is frequently suggested that quackgrass pays its own way in grain and hay rotations by insuring hay and pasture stands when seedings fail or when established mixtures thin out. The cost of such insurance is extremely high in terms of lowered production, reduced feeding value of forage crops, and increased tillage costs.

Bromegrass, in addition to the advantages cited above, is an aggressive sod-former with growth habits similar to quackgrass. It develops vigorous underground rootstocks which enable it to spread rapidly. Normally, bromegrass stands increase in density and productiveness during the second and third years (5, 8). This spreading characteristic permits it to fill in vacant places left by alfalfa or other legumes as they disappear from a hay or pasture mixture. The value of this behavior in weed control has been cited by numerous investigators: Ahlgren and Burcalow (1), Rather and Harrison (6), and Wheeler (8, pp. 66, 513).

While bromegrass shares its vigorous spreading characteristic with quackgrass, it has not proved troublesome as a weed in Michigan. Smooth bromegrass plants are as readily eliminated by plowing and normal tillage as timothy or Kentucky bluegrass (6).

The data reported in this paper were obtained from an experiment established at the Upper Peninsula Experiment Station, Chatham, Michigan, for the purpose of studying the effect of planting date on the performance of several forage crops and mixtures. The original investigation is still in progress. The data presented here support the observations cited above with regard to the value of bromegrass in controlling weeds in legume-grass mixtures. It refers specifically to the effectiveness of bromegrass in reducing the encroachment of quackgrass in hay meadows.

PROCEDURE

Seven forage crops and mixtures were established in duplicated plots with three dates of planting in 1948. The plots were located on Trenary loam, with a pH of 6.0. The area had been seeded in 1944 to a four-to-one mixture of alfalfa and alsike clover. Only one hay crop was removed, in 1945. The remainder of the 1945 season was devoted

to intensive summer fallow in preparation for potatoes in 1946. Spring grain was planted in 1947.

Following grain harvest in August 1947, the field was again subjected to intensive summer fallow tillage with a field cultivator at intervals of one to two weeks until late fall. This cultivation program for the control of quackgrass was resumed in early spring of 1948 and continued until the time that each date-of-planting block was planted.

An application of lime (1 ton per acre) was made in the spring of 1948 and worked thoroughly into the soil. Fertilizer, at the rate of 400 pounds per acre of 0-20-20, was drilled at the time each block was planted.

The seedings of forage crops and mixtures were broadcast by hand. The plots were cultipacked before and after seeding.

The spring seeding was made in barley on May 22. This must be considered a late spring planting for the area. The barley was drilled at the rate of 2 bushels per acre. It made poor growth because of an apparent nitrogen shortage, but it was allowed to mature and was cut for grain in late August.

Two summer plantings were made without a companion crop on July 13 and August 7.

Generally spotty stands, particularly of the grasses, were secured with the late spring planting. Excellent stands of grasses and legumes resulted from the two summer seedings.

Precipitation was below normal during the fore part of the summer. Temperatures were above normal throughout the season. Favorable distribution of rainfall, starting in July and continuing through the remainder of the growing season, promoted rapid growth of the summer seedings.

Very little winter-killing occurred during 1948-49. The winter of 1949-50 was open until February. Scattered ice patches were formed during this period by the freezing of rain and melted snow. A heavy snow cover was formed in mid-February. This kept the iced areas frozen until the last of April. Alfalfa stands were completely destroyed in these spots. The Ladino and Ladino-grass plots largely escaped these ice-patches and came through in the spring of 1950 with stands intact.

Estimates of botanical composition were made on all plots at the time the second year's hay fields were taken in 1950. These data are tabulated in Table 1.

Table 1—Effect of planting date and seeding mixture on the botanical composition of the second year's hay crop, with particular reference to quackgrass and other species foreign to the mixture planted

Crop No.	Seeding rate and forage crops or mixture	Species	1948 Planting Date			6-plot average of total foreign species
			May 22*	July 13†	August 7†	
			2-plot average	2-plot average	2-plot average	
			percent	percent	percent	percent
1.....	8 pounds Hardigan alfalfa....	Alfalfa.....	30	35	80	51.6
		Quackgrass.....	70	65	12	
		Other grasses...	0	0	5	
		Weeds‡.....	0	0	3	
2.	8 pounds ladak alfalfa.....	Alfalfa.....	30	30	82	52.5
		Quackgrass.....	70	70	15	
		Other grasses...	0	0	3	
3.....	2 pounds Ladino clover.....	Ladino.....	8	18	13	87.5
		Quackgrass.....	88	82	55	
		Weeds‡.....	4	.....	32	
4.....	1 pound Ladino clover plus 1 pound Timothy	Ladino.....	5	8	5	24.1
		Timothy.....	48	77	85	
		Quackgrass.....	47	15	10	
5.....	2 pounds Ladino clover plus 4 pounds Timothy	Ladino.....	3	12	8	28.3
		Timothy.....	35	73	85	
		Quackgrass.....	62	15	7	
6.....	2 pounds Ladino clover plus 2 pounds Bromegrass	Ladino.....	Trace	Trace	Trace	16.0
		Brome.....	60	92	99	
		Quackgrass.....	40	8	Trace	
7.....	1 pound Ladino clover plus 4 pounds Bromegrass	Ladino.....	Trace	Trace	Trace	5.4
		Brome.....	85	99	99	
		Quackgrass.....	15	1	Trace	

*Seeded in barley.
†Seeded alone.
‡Note: Annuals and winter annuals: Lambsquarters, pigweed, shepherd's-purse.

A difference of 26.9 percent in total of foreign species (quackgrass, "other grasses" and weeds) is necessary for significance between 2-plot averages. A difference of 15.5 percent is necessary for significance between 6-plot averages.

A single cutting of hay was harvested for yield in both 1949 and 1950. Yields of dry hay for the two years are shown in Table 2.

RESULTS

It has been pointed out that a rigorous sequence of quackgrass control measures, dating back to 1944, had been employed on these plots before they were planted to the various forage crops and mixtures in 1948. The data in Table 1 show the extent to which quackgrass had re-established itself in these forage plantings two years after seeding. The temporary nature of quackgrass control by tillage practices alone is apparent.

The best control and the lowest recovery of quackgrass in all cases occurred where summer fallow was continued until the August 7 planting date. Even here, however, sufficient viable rootstocks and seeds had been left in the soil to permit quackgrass to re-establish itself in the straight Ladino seeding (Table 1, Crop No. 3) to the extent of 55 percent of the stand.

The recovery of quackgrass in the pure alfalfa plantings (crops 1 and 2) was less than in Ladino clover. It was significantly less for the August 7 seeding where quackgrass had been brought under better control by cultivation.

The presence of timothy in the mixtures with Ladino clover reduced the percentage of quackgrass in the second year's hay crop. This reduction, as compared with straight Ladino, was statistically significant for the two summer seedings and closely approached significance

Table 2—Yields of dry hay in 1949 and 1950 for seven forage crops and mixtures and three dates of planting

Crop No.	Seeding rate and forage crops or mixture	Harvest year	1948 Planting Date					
			May 22*		July 13†		August 7†	
			Annual 2-plot average	2-year total	Annual 2-plot average	2-year total	Annual 2-plot average	2-year total
			Lb./A.	Lb./A.	Lb./A.	Lb./A.	Lb./A.	Lb./A.
1.....	8 pounds Hardigan alfalfa....	1949	2,156		3,180		2,810	
		1950	4,615	6,771	4,075	7,255	4,272	7,082
2.....	8 pounds Ladak alfalfa.....	1949	2,889		3,768		2,860	
		1950	4,096	6,985	4,469	8,237	4,760	7,620
3.....	2 pounds Ladino clover.....	1949	1,815		1,946		2,047	
		1950	3,671	4,486	2,779	4,725	2,478	4,525
4.....	1 pound Ladino clover plus 1 pound Timothy	1949	1,967		2,352		2,236	
		1950	3,775	5,742	3,453	5,805	4,324	6,560
5.....	2 pounds Ladino clover plus 4 pounds Timothy	1949	1,997		2,730		2,955	
		1950	3,557	5,554	3,744	6,474	4,096	7,051
6.....	2 pounds Ladino clover plus 2 pounds Bromegrass	1949	1,997		2,621		2,766	
		1950	4,189	6,186	5,455	7,076	5,258	8,024
7.....	1 pound Ladino clover plus 4 pounds Bromegrass	1949	1,997		2,374		2,882	
		1950	4,418	6,415	5,548	7,922	5,226	8,108
Differences required for significance.....		1949	784		784		784	
		1950	747	1,289	747	1,289	747	1,289

*Seeded in barley.
†Seeded alone.

on the late spring planting where quackgrass was poorly controlled by summer fallow.

The data in Table 1 show that bromegrass practically eliminated the re-establishment of quackgrass following the August 7 planting in the Ladino-brome mixtures (crops 6 and 7). The percentage of quackgrass was somewhat higher for the July 13 planting. The contrast with the three straight legume seedings is equally striking, however.

A considerable amount of quackgrass appeared in the Ladino-brome plots which were planted May 22, although the percentage was less than for any other crop or mixture. The increase for this date of planting was due to poorer initial control of quackgrass and unsatisfactory stands of brome. The poor stands of bromegrass on these plots are largely due to the late seeding date and the use of an excessively high rate of planting for the companion crop. Under these adverse conditions, the stand was improved by increasing the rate of seeding from 2 pounds per acre of bromegrass to 4 pounds per acre. The intrusion of quackgrass was accordingly reduced for the mixture with the higher proportion of brome.

The data in Table 1 indicate that, in 1950, the straight Ladino clover seeding was, for all practical purposes, a Ladino-quackgrass mixture. A comparison of the 1950 yields for this mixture (Table 2, Crop 3) with those for the Ladino-timothy and Ladino-brome mixtures very strongly supports the evidence cited earlier that quackgrass is the least productive grass species of the three. This, of course, may not be true at very low levels of soil fertility which will not support stands of timothy or bromegrass.

Hay yields in 1950 were considerably higher for all crops and mixtures than in 1949. This seasonal variation could be due to higher rainfall and cooler temperatures during the spring and early summer of 1950. The average increase for all Ladino-timothy plots was 61 percent, for all Ladino-brome plots 106 percent. The greater increase in second-year yields for the Ladino-brome mixtures is due to the characteristic thickening of the stand of bromegrass which results from its vigorous sod-forming nature. Timothy, a bunch grass, spreads very little. It is also short-lived under climatic conditions encountered in the upper peninsula. Normally, stands of timothy become progressively thinner after the first year.

SUMMARY AND CONCLUSIONS

An experiment including seven forage crops and mixtures and dates of planting (May 22, July 13, August 7) was established on Trenary loam (pH 6.0) at the Upper Peninsula Experiment Station, Chatham in 1948.

The results obtained may be summarized as follows:

1. Quackgrass spreads very rapidly in stands of short-lived legumes and grasses such as clovers and timothy, resulting in lower yields of hay. It also replaces winter-killed areas in established alfalfa stands.

2. Control of quackgrass by summer fallowing is at best a temporary measure because enough viable rootstocks and seed remain in the soil to provide for rapid recovery of the quackgrass stand.

3. Bromegrass is a very effective competitor with quackgrass for space in a thinning legume stand.

4. The data, as interpreted, in no way minimize the importance of summer fallow in securing initial control of severe infestations of quackgrass. However, good bromegrass stands will permit this initial control of quackgrass by summer fallowing to persist over a period of two or three rotations. Thus, the elimination of quackgrass as an economic pest in grain and hay rotations becomes a practical possibility.

5. Higher yields of hay were obtained from the July and August plantings than from the May seeding.

6. The effectiveness of this proposed method for quackgrass control is dependent on the maintenance of an adequate level of soil fertility to support good stands of brome and adapted legumes and on proper seeding methods.

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THE CHEMICAL COMPOSITION AND NUTRITIVE VALUE OF YELLOW DENT CORN GRAIN: I. THE IRON, MANGANESE AND GROSS CALORIE CONTENT

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Corn, both as a cereal grain and as a forage crop, is one of the most important crops grown in the United States. From the standpoint of production it occupies second place among the food plants of the world. It is highly palatable, rich in total digestible nutrients, and is the chief cereal grain used in livestock feeding for the efficient production of meat and milk.

Because of corn's preponderance in practical rations for farm animals, it is desirable to have as much information as possible concerning the composition of corn grain to serve as a guide to its nutritive value. Early studies were concerned chiefly with its proximate composition, but with the recognition of the importance of trace elements in both animal and human nutrition, more attention has been given to the determination of these nutrients in cereal grains.

In making recommendations on the nutrient requirements of farm animals and poultry, the Committee on Animal Nutrition of the National Research Council found that the amount of available information on the mineral and vitamin contents of feed ingredients was very limited. A Committee on Feed Composition was appointed by the National Research Council to conduct various survey projects to be determined by statistical calculations based on climate, soil characteristics and total production for the collection of various feed stuffs. The committee was keenly aware of the paucity of information on the composition of the yellow dent corn hybrids and decided to study this grain as the first project. State agronomists selected the samples according to the recommendations of the Committee, and State Control laboratories, industrial laboratories and agricultural experiment sta-

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tions were asked to make the proximate, mineral and vitamin analyses. Two short papers have been published (2, 3), but much of the data remain unpublished because the Committee has been suspended because of lack of funds.

This paper contains some of the unpublished data on the corn supplied by the Committee on Feed Composition and reports the proximate composition, iron, manganese and gross calorie content of 25 samples of yellow dent corn grown in selected areas in the United States.

EXPERIMENTAL

Each sample was ground in a Wiley mill to pass a 20-mesh sieve and preserved in tightly stoppered brown bottles for subsequent analysis, except for the determination of iron. A representative sample of the whole corn grain was selected for this determination to avoid contamination with any metal surfaces.

The moisture, ash, nitrogen, ether extract, crude fiber, calcium and phosphorus determinations were carried out according to standard A.O.A.C. procedures (1). The iron and manganese determinations were made according to the procedures outlined by Bandemer and Schaible (7) and Bandemer *et al.* (8), respectively. The gross calories were determined in triplicate according to the standard procedure submitted by the manufacturer of the Parr sodium peroxide calorimeter.

RESULTS AND DISCUSSION

The geographical origin of the individual samples of corn together with the ash, calcium, phosphorus, iron, manganese, protein, ether extract and crude fiber contents are presented in Table 1. The ash, ether extract and protein content of all of the samples were fairly constant and varied the least of the eight constituents. The average value obtained for each was 1.23, 4.5 and 10.4 percent, respectively. The amounts of iron, manganese and crude fiber in the samples showed more variation than did the ash, ether extract and protein, whereas the calcium and phosphorus showed the greatest variation.

The data in Table 1 indicate that the content of the constituents does not vary markedly from one geographical area to another but that maximum and minimum concentrations may occur within a given state, i.e., the calcium content of the corn from Iowa. With the exception of calcium and phosphorus, and to a lesser extent iron and

Table 1—The chemical composition of yellow dent corn grown in various sections of the United States (All values expressed on the moisture-free basis)

Source of samples	Ash	Ca	P	Fe	Mn	Protein	Ether extract	Crude fiber
County and state	%	%	%	mg./kg.	mg./kg.	%	%	%
Coosa, Ala.	1.29	.....	.....	19.0	7.4	10.1	5.0	2.4
Otero, Colo.	1.20	0.011	0.29	20.8	5.5	8.2	4.9	2.0
Clinton, Ind.	1.28	0.006	0.25	26.1	3.9	9.9	4.5	2.6
DeKalb, Ind.	1.35	0.011	0.32	22.8	4.8	11.4	4.7	2.3
Huntington, Ind.	1.19	0.015	0.18	23.0	4.8	9.1	3.6	2.2
Tippecanoe, Ind.	1.31	.....	0.53	26.7	5.1	10.7	4.7	2.7
Benton, Iowa.	1.14	.....	.....	23.4	5.9	9.6	4.4	2.5
Black Hawk, Iowa.	1.05	0.027	0.25	21.2	5.0	10.4	4.3	2.3
Buena Vista, Iowa.	1.22	0.012	0.29	22.3	4.3	11.0	4.8	2.1
Clay, Iowa.	1.26	.....	.....	29.6	6.1	10.8	4.7	2.2
Hamilton, Iowa.	1.18	0.032	0.34	24.0	5.4	10.9	3.4	2.4
Kossuth, Iowa.	0.97	0.015	0.27	19.5	3.4	10.2	4.5	2.4
Mills, Iowa.	1.26	0.024	.....	22.5	4.2	9.9	4.1	2.1
Mitchell, Iowa.	1.26	0.006	0.59	30.0	4.6	10.6	4.1	3.0
Osceola, Iowa.	0.97	0.018	0.19	24.5	5.0	10.5	4.8	2.4
Story, Iowa.	1.18	0.012	0.26	22.6	5.0	9.4	4.3	2.1
Winneshiek, Iowa.	1.16	0.033	0.21	26.5	6.3	10.8	4.6	2.4
Jackson, Kans.	1.34	0.008	0.29	24.5	6.6	8.7	5.2	2.3
Marion, Kans.	1.26	0.020	0.27	27.5	5.3	10.3	4.3	2.6
Pottawatomi, Kans.	1.35	.....	0.45	25.9	7.1	12.6	4.7	2.6
Lafayette, Mo.	1.27	.....	.....	25.5	6.4	11.2	4.9	2.4
Ralls, Mo.	1.22	0.011	0.20	22.5	7.0	10.9	5.5	2.3
Douglas, Nebr.	1.47	0.036	0.35	34.8	6.3	11.9	4.4	3.3
Otoe, Nebr.	1.29	0.006	0.31	24.4	5.0	9.7	4.8	2.1
Sargent, N. D.	1.30	0.031	0.24	25.2	7.3	11.7	4.1	2.2
Mean.	1.23	0.018	0.30	24.6	5.5	10.4	4.5	2.4
Coef. of var. (%).	9.3	55.6	36.0	14.3	19.7	9.6	10.0	12.5

manganese, the concentrations of protein, ether extract, and crude fiber were remarkably uniform in all of the samples. Although the data are not concerned primarily with the percentage composition of these constituents, they do show good agreement with the majority of the published values. As mentioned previously, the calcium and phosphorus values show wide variations, and some authorities have emphasized that comprehensive data are lacking insofar as these constituents are concerned (2, 23). Attention should be called to the sixfold difference found in the calcium content of the corn.

No correlation was found between the ash content and the calcium or phosphorus contents, but a significant correlation was found be-

tween the protein content and the crude fiber content ($r = 0.458^*$). There was no correlation between the protein content and ether extract content.

In order to make available as much information as possible concerning the iron and manganese content of corn, Tables 2 and 3 have been included to summarize the data published in the United States and to indicate the paucity and variation among these data.

Iron—Iron has been recognized for many years as an important constituent for the adequate nutrition of both plants and animals, but data regarding the iron content of feeding stuffs consumed by farm animals is fragmentary. Probably one reason for this lack of informa-

Table 2—Literature values recorded for the iron content of corn (All values expressed as mg./kg.)

Reference	No. of samples	Minimum	Mean	Maximum	Variety
Skinner and Peterson (30)	.....	.....	44.8	.....	Yellow
Peterson and Elvehjem (26)	.....	.....	31.5	.....	White
Peterson and Elvehjem (26)	.....	.....	24.9	.....	Yellow
Fraps (18)	2	36.0	.....	65.0	Yellow
Fraps (18)	9	28.0	42.0	75.0	White
Fraps (18)	4	36.0	49.0	74.0	Red
Maranon (22)	.....	.....	49.0	.....	Philippine
Word and Wakeman (35)	2	22.8	.....	29.7	Yellow
Ranganathan (27)	.....	.....	20.8	.....	India
Chang (11)	.....	.....	16.0	.....	China
Soliven and Laurel (31)	.....	.....	40.0	.....	Philippine
Holland and Ritchie (19)	.....	.....	47.0	.....	Yellow
Holland and Ritchie (19)	.....	.....	44.0	.....	White*
Holland and Ritchie (19)	.....	.....	40.0	.....	Yellow†
Beeson (9)	4	25.0	37.0	50.0	.....
Crawford *et al.* (12)	.....	.....	31.0	.....	White‡
Crawford *et al.* (12)	.....	.....	58.0	.....	Wh. flint‡
Crawford *et al.* (12)	.....	.....	55.0	.....	Yel. flint‡
National Research Council (3)	38	.....	23.0	.....	Yellow
National Research Council (3)	1	.....	29.5	.....	Argentina
National Research Council (3)	2	.....	18.0	.....	Blue
National Research Council (3)	2	.....	20.0	.....	Popcorn
Morrison (23)	.....	.....	30.0	.....	No. 2, Yel.
Weeks and Fergus (34)	132	16.0	28.7	90.0	White§
Weeks and Fergus (34)	92	10.0	32.2	86.0	White¶
This paper	25	19.0	24.6	34.8	Yellow

*Red-cob white.
†Argo-ensilage.
‡Grown in South Africa.
§Kentucky grown hybrid.
¶Kentucky grown open-pollinated.

*Significant at 5-percent level.

tion is because iron deficiencies in mammals are not known to occur frequently, except in nutritional anemia of suckling pigs.

The average value obtained in this investigation was 24.6 mg./kg., with a range of 19.0 to 34.8. The coefficient of variation was 14.3 percent. The average value is in good agreement with the limited values published by Peterson and Elvehjem (26), the National Research Council (3) and Morrison (23) for yellow dent corn, but is considerably lower than those values recorded by Skinner and Peterson (30), Fraps (18), Holland and Ritchie (19) and Beeson (9).

It is entirely possible that the marked variations recorded in the literature may have resulted from the various chemical methods employed for its determination, contamination with iron during the transport or treatment of the samples or in actual differences in the iron content of the corn due to its availability in the soil.

Several values have been included in Table 2 for corn grown and consumed in foreign countries by both human beings and animals. The values recorded for corn grown in the Philippine Islands (22, 31) and South Africa (12) are comparable to the higher mean values reported in the United States, but corn grown in India (27) and China (11) apparently contains significantly lower amounts than that grown in this country.

A highly significant correlation was found to exist between the ash content and the iron content of corn ($r = 0.517^{**}$).

On the basis of the results reported in this paper, yellow dent corn contains considerably less iron than the published values for barley, rye, oats and wheat (30).

Manganese—This element is a universal constituent of all plant and animal tissues, but very little is known regarding its specific physiologic functions in living cells. Whatever the function of manganese may be, there is no doubt of its common occurrence in soils and of its utilization by plants in limited amounts, but analytical data indicative of the actual amounts found in corn are not common. The cereal grains, however, contribute the most to the manganese intake of both human beings and farm animals.

The average value obtained from this work was 5.5 mg./kg., with a range of variation from 3.4 to 7.4. The coefficient of variation was 19.7 percent. This average value is in good agreement with the literature values reported in this country (Table 3), except for those re-

**Significant at the 1-percent level.

Table 3—Literature values recorded for the manganese content of corn (All values expressed as mg./kg.)

Reference	No. of samples	Minimum	Mean	Maximum	Variety
Lindow and Peterson (20)	.....	.....	5.3	.....	Yellow
Skinner and Peterson (30)	.....	.....	5.4	.....	Yellow
Davidson (13)	5	6.5	7.9	13.0	.....
Schaible *et al.* (29)	25	3.9	4.9	7.8	Yellow
Moxon and Lardy (25)	6	2.0	5.5	9.0	.....
Holland and Ritchie (19)	.....	.....	13.0	.....	Argentina
Holland and Ritchie (19)	.....	.....	5.0	.....	Yellow
Holland and Ritchie (19)	.....	.....	18.0	.....	White*
Holland and Ritchie (19)	.....	.....	6.0	.....	Yellow†
Beeson (9)	13	5.0	13.0	19.0	.....
Motzok *et al.* (24)	3	7.0	7.0	8.0	Africa
Motzok *et al.* (24)	5	5.0	8.0	14.0	Yellow
Motzok *et al.* (24)	2	7.0	.....	8.0	Argentina
Motzok *et al.* (24)	10	4.0	6.0	14.0	Yel. (Can.)
Motzok *et al.* (24)	3	3.0	5.0	6.0	Wh. (Can.)
National Research Council (3)	49	.....	6.4	.....	Yellow
National Research Council (3)	1	.....	16.1	.....	White
National Research Council (3)	1	.....	11.7	.....	Argentina
Underwood *et al.* (33)	6	6.5	8.6	11.6	Australia
Morrison (23)	.....	.....	5.5	.....	No. 2 Yel.
Weeks and Fergus (34)	127	2.0	5.0	12.0	White‡
Weeks and Fergus (34)	93	2.0	6.3	12.0	Yellow§
This paper	25	3.4	5.5	7.4	Yellow

*Red-cob white.
†Argo-ensilage.
‡Kentucky grown hybrid.
§Kentucky grown open-pollinated.

ported by Beeson (9). Examination of the data in Table 3 show that the white and yellow varieties do not differ significantly in their manganese contents. Corn, however, contains markedly less manganese than barley, rye, oats, rice and wheat (13, 20, 29, 30).

A significant correlation was found between the ash content and manganese content ($r = 0.401^*$).

Gross Calories—When an organic substance is completely burned to its ultimate oxidation products, the maximum amount of heat given off represents its heat of combustion. When digestible carbohydrates or fats are oxidized in the body they yield the same ultimate oxidation products as when they are burned outside of the body. The amount of heat given off in both types of oxidation is the same per unit of substance; therefore, the heat of combustion or gross calories value

*Significant at the 5-percent level.

can be used as the starting point in the determination of the energy value of feed concentrates.

Thirty-eight samples of corn were made available for the determination of gross calories. Their source of origin and the results obtained from this work are presented in Table 4. The average gross calorie value was 4,716 (range 4,546 to 4,967), with a coefficient of variation of only 1.7 percent. From an inspection of the data it can be seen that the highest and lowest values were found to occur in samples of corn from Iowa. None of the values from the other states was significantly higher or lower than the average value, indicating that the calorie content of these samples was rather uniform.

Table 4—The gross calories in yellow dent corn harvested in various sections of the United States (All values expressed on the moisture- and ash-free basis as calories (c) per gram)

Source of samples—County and state		Source of samples—County and state	
Coosa, Alabama	4,816	Mills, Iowa	4,767
Otero, Colorado	4,722	Mitchell, Iowa	4,817
Champaign, Illinois	4,666	Osceola, Iowa	4,791
Effingham, Illinois	4,683	Polk, Iowa	4,628
Gallatin, Illinois	4,673	Poweshiek, Iowa	4,546
Knox, Illinois	4,651	Story, Iowa	4,710
McLean, Illinois	4,727	Winneshiek, Iowa	4,569
Piatt, Illinois	4,626	Jackson, Kansas	4,833
Tazewell, Illinois	4,710	Marion, Kansas	4,795
Clinton, Indiana	4,630	Pottawatomi, Kansas	4,799
DeKalb, Indiana	4,675	Mower, Minnesota	4,701
Huntington, Indiana	4,682	Murray, Minnesota	4,556
Tippecanoe, Indiana	4,756	Todd, Minnesota	4,683
Benton, Iowa	4,643	Lafayette, Missouri	4,778
Black Hawk, Iowa	4,778	Ralls, Missouri	4,846
Buena Vista, Iowa	4,967	Douglas, Nebraska	4,771
Clay, Iowa	4,823	Otoe, Nebraska	4,648
Hamilton, Iowa	4,662	Sargent, North Dakota	4,765
Kossuth, Iowa	4,669	Franklin, Pennsylvania	4,759
Mean	4,716		
Coefficient of variation (%)	1.7		

The literature values recorded for the gross calories content are shown in Table 5. Apart from these studies, very little attention has been given to the actual determination of the heat of combustion of corn. It should be pointed out, however, that the values reported in this paper are approximately 6 percent higher than those reported by

Table 5—Literature values recorded for gross calories (c) per gram of corn

Reference	No. of samples	Minimum	Mean	Maximum	Variety
Richards (28)	.....	.....	4,130	.....	Yellow
Richards (28)	.....	.....	4,228	.....	White
Armsby and Fries (4)	2	4,403	.....	4,459	Yellow
Armsby and Fries (5)	4	4,360	4,440	4,526	Yellow
Armsby *et al.* (6)	2	4,496	.....	4,515	Yellow
Spitzer *et al.* (32)	2*	4,243	.....	4,354	Yellow
DeBaufre (14)	2	4,510	.....	4,543	White
DeBaufre (15)	2	4,529	.....	4,551	Yellow
Forbes *et al.* (17)	2	4,538	.....	4,551	Yellow
Malhotra (21)	.....	.....	3,480	.....	India
Carpenter and Steggerda (10)	.....	.....	4,366	.....	White
Carpenter and Steggerda (10)	.....	.....	4,550†	.....	.....
Carpenter and Steggerda (10)	.....	.....	4,407‡	.....	.....
Carpenter and Steggerda (10)	.....	.....	4,526§	.....	.....
Fester and Schivazappa (16)	.....	.....	4,700	.....	Argentina
National Research Council (2)	56	4,274	4,448	4,967	Yellow
This paper	38	4,546	4,716	4,967	Yellow

*Soft corn.
†Yellow and blue Indian corn.
‡Navajo Indian white.
§Maya white.

the National Research Council (2), after their values had been recalculated to the moisture-free basis.

The number of samples used in compiling these data are not large but they make an appreciable contribution to the limited information on the composition of yellow dent corn grain and will be useful to animal nutritionists, feed manufacturers and specialists in making recommendations for feed formulations.

SUMMARY

Twenty-five samples of yellow dent corn, grown in various sections of the United States, were analyzed for ash, calcium, phosphorus, iron, manganese, protein, ether extract and crude fiber. The gross calorie content was determined in 38 samples.

The average and range of values for iron, manganese and gross calories were found to be 24.6 (range 19.0 to 34.8), 5.5 (range 3.4 to 7.4) mg./kg., and 4,716 (range 4,546 to 4,967) c. g., respectively.

Similarities and differences with the literature values were indicated.

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THE CHEMICAL COMPOSITION AND NUTRITIVE VALUE OF YELLOW DENT CORN GRAIN: II. THE THIAMIN, RIBOFLAVIN, NIACIN AND PANTOTHENIC ACID CONTENT

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THE GRAIN produced by any corn plant depends to a great extent upon the inherited characteristics of the plant and the environmental conditions under which it is grown. It is generally assumed that environmental factors and yield influence the chemical composition of corn. It is also recognized that the genetic constitution of the corn plant influences its chemical composition, but very few publications show conclusively the effect of inheritance or environment upon the constituents in corn grain. Since a large proportion of the caloric intake of many human beings and farm animals is made up of cereal grains and their products, comprehensive information concerning their vitamin levels is of more than passing interest. The factors which influence the elaboration of or are related to the vitamin content of corn is far from being exhausted.

The object of this paper is to report the results obtained from the analysis of 25 samples of yellow dent corn, grown in commercially important corn-producing areas of the United States, for the thiamin, riboflavin, niacin and pantothenic acid contents. This project was sponsored by the Committee on Feed Composition of the National Research Council. It was for the purpose of compiling as much information as possible on the composition of corn in order to make adequate recommendations on the nutritive requirements of farm animals and poultry, as indicated in a previous paper (14).

EXPERIMENTAL

Each sample of corn was ground in a Wiley mill to pass a 20-mesh sieve and stored in a tightly stoppered brown glass bottle for subsequent analysis.

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Thiamin was determined by the thiochrome method of Hennessey (20) after a 2-gram sample had been digested with 0.1*N* sulfuric acid on a steam bath for 30 minutes, cooled to room temperature, and then incubated at 50° C. for 4 hours after the addition of 2.5*N* sodium acetate and 0.3 gram of taka-diastase. Any non-thiamin fluorescent substances were eliminated by the procedure proposed by Mickelsen *et al.* (29).

Riboflavin was determined by the method proposed by Snell and Strong (38) after an extract had been prepared by autoclaving a 1-gram sample in 0.1*N* hydrochloric acid for 30 minutes at 15 pounds pressure, cooled to room temperature, centrifuged at 3,500 r.p.m. for 15 minutes and an aliquot adjusted to pH 4.6 with sodium hydroxide. The filtrates were placed in low actinic flasks and stored in the refrigerator until analyzed. *Lactobacillus casei* (7469) was used as the test organism.

The method of Krehl *et al.* (26) was used to determine niacin. The sample was prepared in the same manner as for riboflavin except that 1.0*N* hydrochloric acid was used for the extraction. *Lactobacillus arabinosus* 17–5 (8014) was used as the test organism.

The method of Skeggs and Wright (37), with the modifications suggested by Buskirk *et al.* (9), was used to determine pantothenic acid. A 1-gram sample was digested with 1 gram of Mylase P, buffered to pH 4.2-4.5 with 2-percent acetic acid and 1.0*N* sodium hydroxide, and incubated for 2-3 hours at 50° C. The same test organism was used as for niacin.

RESULTS AND DISCUSSION

The amounts of thiamin, riboflavin, niacin and pantothenic acid found in the yellow dent corn samples are presented in Table 1. From the data presented in this table, it is not possible to establish any relationship between the geographical location in which the corn was grown and the amount of the various B-vitamins found in the samples. Approximately the lowest and highest amounts of thiamin were recorded for two samples from Kansas, the widest variation for riboflavin occurred in the samples from Iowa, whereas Indiana corn showed the greatest variation in pantothenic acid content. These observed differences are quite obvious but the complete explanation for the differences is comparatively obscure.

Table 1—The thiamin, riboflavin, niacin and pantothenic acid (P.A.) *content of corn grain grown in various sections of the United States* (*All values expressed as milligrams per kilogram on the moisture-free basis*)

Source of sample—county and state	Thiamin	Riboflavin	Niacin	P.A.
Coosa, Alabama	4.76	0.89	31.69	6.84
Otero, Colorado	4.79	0.92	32.01	6.07
Clinton, Indiana	4.58	1.02	29.65	7.44
DeKalb, Indiana	4.94	1.21	26.97	6.28
Huntington, Indiana	4.62	1.06	27.55	8.13
Tippecanoe, Indiana	5.07	0.93	26.56	5.46
Benton, Iowa	4.91	1.01	27.03	6.70
Black Hawk, Iowa	4.91	1.22	30.96	7.05
Buena Vista, Iowa	4.43	1.03	29.18	5.93
Clay, Iowa	5.57	1.11	31.33	6.60
Hamilton, Iowa	4.56	0.88	30.32	6.58
Kossuth, Iowa	4.94	0.97	25.91	6.13
Mills, Iowa	4.52	1.03	25.24	5.55
Mitchell, Iowa	4.60	1.01	27.91	5.94
Osceola, Iowa	4.75	1.02	32.46	7.69
Story, Iowa	4.78	0.89	31.44	5.80
Winneshiek, Iowa	4.74	1.02	23.94	6.66
Jackson, Kansas	4.52	1.00	28.30	5.75
Marion, Kansas	6.57	1.01	27.01	5.26
Pottawatomi, Kansas	4.77	0.94	23.06	4.75
Lafayette, Missouri	4.69	1.28	25.02	6.53
Ralls, Missouri	4.69	1.06	27.13	7.18
Douglas, Nebraska	4.68	1.11	21.60	6.39
Otoe, Nebraska	4.28	0.90	29.96	5.47
Sargent, North Dakota	6.76	1.02	29.85	8.32
Mean	4.90	1.02	28.08	6.42
Coefficient of variation	12.0	10.2	10.4	13.8

Table 2 shows the marked variations in the literature values recorded for the thiamin and riboflavin contents of corn and also the small number of values available for comparative purposes.

Thiamin—The average value obtained from this study was 4.9 mg./kg., which is in fair agreement with the higher mean literature values for corn grown in the United States. Golberg and Thorp (17) reported an average value of 2.8 for yellow corn grown in South Africa, whereas Ahmad *et al.* (1), in India, reported a value of 2.13 for maize. These values approach the minimum values obtained by workers in this country. Some investigators (12, 15, 17, 31) have shown that the concentration of thiamin in white corn is higher than that found in yellow corn.

Table 2—Literature values recorded for the thiamin and riboflavin content of corn (Expressed as mg./kg.)

Reference	No. of samples	Minimum	Mean	Maximum	Variety
Thiamin					
Schultz *et al.* (36)	23	4.1	5.34	8.0	Yellow
Conner and Straub (12)	12	2.54	4.40	7.40	White
Conner and Straub (12)	16	2.33	3.80	5.93	Yellow
Nordgren and Andrews (31)	6	4.82	5.37	6.20	Yellow
Nordgren and Andrews (31)	6	4.93	6.07	6.69	White
Ellis and Madsen (15)	28	2.33	4.88	7.39	White
Ellis and Madsen (15)	41	2.33	4.53	7.88	Yellow
Golberg and Thorp (17)	49	2.34	3.02	3.87	White
Golberg and Thorp (17)	9	2.43	2.91	3.42	Wh. flint
Golberg and Thorp (17)	23	2.34	2.80	3.48	Yellow
Golberg and Thorp (17)	24	2.40	2.93	3.92	Yel. flint
Golberg and Thorp (17)*	22	2.34	2.83	3.48	.....
Golberg and Thorp (17)†	16	2.40	2.85	3.39	.....
Golberg and Thorp (17)‡	17	2.34	3.31	3.78	.....
National Research Council (3)	39	.....	3.96	.....	Yellow
Morrison (30)	.....	.....	4.18	.....	Yellow
Hunt *et al.* (23)	34	2.90	4.65	6.90	Yellow
This paper	25	4.28	4.90	6.76	Yellow
Riboflavin					
Conner and Straub (12)	12	0.92	1.32	2.29	White
Conner and Straub (12)	16	0.84	1.30	2.02	Yellow
Andrews *et al.* (2)	6	1.30	1.40	1.50	Yellow
Andrews *et al.* (2)	5	1.30	1.38	1.50	White
Ellis and Madsen (15)	32	0.84	1.32	2.02	Yellow
Ellis and Madsen (15)	17	0.92	1.34	2.29	White
Evans *et al.* (16)	7	1.00	1.10	1.50	Yellow
National Research Council (3)	6	.....	1.1	.....	White
National Research Council (3)	52	.....	1.1	.....	Yellow
National Research Council (3)	6	.....	1.1	.....	Popcorn
Morrison (30)	.....	.....	1.1	.....	Yellow
Hunt *et al.* (23)	34	0.77	1.06	1.37	Yellow
This paper	25	0.88	1.02	1.28	Yellow

*Effect of fertilizer: none. Grown in South Africa.
†Effect of fertilizer: manure. Grown in South Africa.
‡Effect of fertilizer: superphosphate. Grown in South Africa.

Burkholder and McVeigh (7) studied the growth of two corn hybrids in nutrient media and observed that the thiamin content of corn grain varied directly with the nitrogen supply and inversely with the phosphorus supply. This indicates that the fertility of the soil

may play an important part in determining the thiamin content of corn grain. Golberg and Thorp (17), however, found no difference in the thiamin content of corn grown on untreated or manured soils, but significantly higher concentrations were obtained when corn was grown on soil treated with superphosphate. Hunt *et al.* (23) found from a study of a 5-year rotation fertility experiment that lime increased the thiamin content of corn, whereas potash decreased the thiamin concentration.

Schultz *et al.* (36) found no difference in the thiamin content of various cereal grains, i.e., wheat, barley, oats, corn, rye and buckwheat, but they did observe a significant difference in the thiamin content of the various strains of the same cereal. They also indicated that regional differences may affect the thiamin content of single strains. O'Donnell and Bayfield (32) found that the thiamin content of wheat was influenced by seasonal variations, variety and location, but it appeared to be negatively related to conditions favoring starch synthesis. Pulkki and Puutula (33) observed that a cereal grain having a high natural fat content contained a relatively high level of thiamin. No significant correlation was found between the ether extract content and thiamin content ($r = 0.237$) in these corn samples.

Riboflavin—In spite of the fact that cereal grains are not abundantly endowed with riboflavin, the ingestion of liberal amounts of corn by farm animals and poultry can make an appreciable contribution to their requirements. Nevertheless, there is very little information on the riboflavin content of corn grain.

The experimental values reported in this paper varied from 0.88 to 1.28 (mean 1.02). This value is lower than those recorded by some investigators (2, 12, 15), but is more in agreement with values published recently (3, 16, 23, 30). All of the investigators (2, 3, 12, 15, 41) who have analyzed both white and yellow corn found no difference in the riboflavin content. No correlation was apparent between the ether extract content and riboflavin content or between the protein content and riboflavin content ($r = 0.088$ and $r = 0.317$, respectively).

The addition of lime as a soil amendment was found to decrease the riboflavin content of corn in the fertility experiments conducted by Hunt *et al.* (23).

Table 3 shows the variations and lack of agreement in the literature values recorded for the niacin and pantothenic acid contents of corn.

Niacin—The niacin content of the corn used in this investigation varied from 21.60 to 32.46 mg./kg., with an average value of 28.08. Burkholder *et al.* (8) found from a study of inbred and hybrid lines of corn that genetic factors control the ability of the corn plant to store niacin. Different strains of corn grown in the same field contained widely different amounts of niacin, indicating the importance of inheritance in controlling the niacin content. Hunt *et al.* (21) found that the niacin content was influenced significantly by both hereditary and environmental factors. Subsequent studies by Ditzler *et al.* (13) showed

Table 3—Literature values recorded for the niacin and pantothenic acid content of corn (All values expressed as mg./kg.)

Reference	No. of samples	Minimum	Mean	Maximum	Variety
Niacin					
Aykroyd and Swaminathan (4)	9	.....	13.0	.....	White
Aykroyd and Swaminathan (4)	9	.....	14.0	.....	Yellow
Aykroyd and Swaminathan (4)*	10	12.0	14.0	16.0	Yellow
Burkholder *et al.* (8)	28	12.7	.....	29.4	White
Burkholder *et al.* (8)	30	11.3	.....	36.3	Yellow
Cheldelin & Williams (11)	2	7.4	.....	9.7	White
Tepley *et al.* (39)	8	15.6	.....	26.0	Yellow
Hale *et al.* (19)	.....	17.0	23.3	28.0	Yellow
Thomas *et al.* (40)	.....	.....	8.2	.....	White
Thomas *et al.* (40)	.....	.....	8.1	.....	Yellow
Ellis and Madsen (15)	27	7.0	14.1	21.0	Yellow
Ellis and Madsen (15)	10	9.9	13.3	16.0	White
Krehl *et al.* (27)	.....	.....	22.5	.....	White
Krehl *et al.* (27)	.....	.....	22.8	.....	Yellow
Barton-Wright (5)†	7	11.5	15.6	20.0	Starchy
Mather *et al.* (28)	5	12.4	14.0	16.1	.....
National Research Council (3)	38	.....	24.0	.....	Yellow
National Research Council (3)	6	.....	18.5	.....	White
National Research Council (3)	6	.....	17.2	.....	Popcorn
Hunt *et al.* (21)‡	125	14.3	21.3	29.5	Yellow
Hunt *et al.* (22)	10	19.7	24.1	31.2	Yellow
Hunt *et al.* (23)	34	19.2	23.1	26.0	Yellow
Hunt *et al.* (24)	128	17.0	22.5	30.1	Yellow
Morrison (30)	.....	.....	19.8	.....	Yellow
Richey and Dawson (34)§	99	20.5	24.2	31.5	White
Richey and Dawson (34)¶	28	14.8	18.6	25.4	White
Richey and Dawson (34)**	14	13.9	26.1	53.3	White
Richey and Dawson (34)**	10	15.6	22.2	30.8	Yellow
Gorfinkel (18)	25	14.9	19.6	25.5	White
Gorfinkel (18)	53	15.7	21.8	31.3	Yellow
Rodriguez *et al.* (35)	39	12.4	22.6	54.1	Yellow
This paper	25	21.6	28.1	32.5	Yellow

Table 3 (Concluded)

Reference	No. of samples	Minimum	Mean	Maximum	Variety
		Pantothenic acid			
Jukes (25)	3	8.1	9.2	11.6	Yellow
Cheldelin and Williams (11)	2	3.3	.....	3.6	White
Bauernfeind *et al.* (6)	6	6.0	6.7	9.0	Yellow
Ellis and Madsen (15)	9	6.0	7.4	10.0	Yellow
National Research Council (3)	49	.....	4.6	.....	Yellow
National Research Council (3)	6	.....	3.5	.....	White
National Research Council (3)	6	.....	3.3	.....	Popcorn
Hunt *et al.* (21)‡	125	2.1	5.3	9.5	Yellow
Hunt *et al.* (22)	10	3.4	4.8	6.3	Yellow
Hunt *et al.* (23)	34	4.1	6.4	10.1	Yellow
Hunt *et al.* (24)	128	1.9	4.3	8.6	Yellow
Morrison (30)	.....	.....	5.1	.....	Yellow
Rodriguez *et al.* (35)	39	2.6	6.1	9.4	Yellow
This paper	25	4.8	6.4	8.3	Yellow

*Grown in Roumania.
†Starchy corn.
‡Double-cross hybrid.
§Grown in the South.
¶Grown in the North.
**Inbred lines.

that the niacin content of both single- and double-cross hybrids was related to the niacin content of their component inbred lines, but that the niacin content was less subject to modification by environmental factors than by inheritance. Further work by Hunt *et al.* (24) indicated that certain Ohio-grown hybrid corns were higher in niacin than other hybrid corns and that fertilization was without effect (23). Gorfinkel (18) concluded that the niacin content of corn is a genetically inherited factor. Hunt *et al.* (22) recently reported that the average niacin content of corn was 24.1 mg./kg., whereas some of the same corn which had been allowed to mold contained approximately 50.0 mg. Richey and Dawson (34) found that varieties of white dent corn differed widely in their niacin content and that southern grown varieties tended to be higher than the same varieties grown in the northern part of the United States. In a study of a series of mature maize endosperm genotypes, Cameron and Teas (10) observed that the niacin content was inversely related to the starch content. Sugary types of corn averaged 50.5, whereas the starchy types averaged 24.2 mg./kg., on the air-dry basis.

Corn grown in India and in pellagra districts of Roumania has been shown to contain somewhat less niacin than is found in corn grown in this country (4).

A significant negative coefficient of correlation was found between the niacin content and protein content of the corn used in this work, but no correlation was found between the niacin content and ether extract content ($r = -0.479^*$ and $r = 0.033$, respectively). Rodriguez *et al.* (35) also found a negative correlation between the niacin content and protein content which approached the 5-percent level of significance. The results of these two findings indicate that some relationship may exist between the protein content and niacin content of corn.

Pantothenic Acid—The average amount of pantothenic acid found in the corn was 6.42 mg./kg. (range 4.75 to 8.32). Hunt *et al.* (21) found that the variations in the pantothenic acid content of double-cross hybrids was due mainly to the season in which the corn was grown and, to a lesser extent, to heredity. Ditzler *et al.* (13), however, observed that the variations in pantothenic acid were conditioned to a large extent by environmental factors, but a definite hereditary influence was manifest when a group of early single-cross hybrids were grown under approximately the same environmental conditions. The inherited ability of the corn plant to elaborate this vitamin is influenced significantly by environmental conditions, whereas the reverse is true for niacin. Hunt *et al.* (22) also found that the pantothenic acid content of moldy corn was markedly higher than that found in normal corn. Subsequent work by Hunt *et al.* (23) has shown that certain Ohio-grown hybrids contain more pantothenic acid than other corn hybrids, but soil fertility experiments failed to influence the concentration of this vitamin (22).

No correlation was found between the pantothenic acid content and protein content or betwen this vitamin and ether extract content in these corn samples ($r = -0.019$ and $r = -0.191$, respectively). Coefficients of correlation were also determined for the various pairs of vitamins, but no significant correlation was apparent except the correlation between niacin and pantothenic acid approached significance at the 5-percent level. These findings confirm those reported by Gorfinkel (18).

Inspection of the data in Table 1 shows that the coefficients of variation were quite uniform for each of the four B-vitamins. Riboflavin and niacin showed the least variation, whereas thiamin and pantothenic acid showed somewhat larger variations. The percentage variations are not large, however, considering the small number of

*Significant at 5-percent level.

samples, the extremes in latitude and longitude, soil types, fertilizer practice, amounts of available sunshine, moisture supply, and the genetic and hereditary factors that were all functioning in the elaboration of each corn grain.

The addition of these data to that already published (3) is basic to the animal nutritionist, feed manufacturer and specialist in understanding the approximate nutritive characteristics and range of values that may be encountered in the formulation of rations for farm animals and poultry.

SUMMARY

The thiamin, riboflavin, niacin and pantothenic acid contents of 25 samples of corn grain, grown in widely separated areas of the United States, have been determined. The average amounts of thiamin, riboflavin, niacin and pantothenic acid found in the samples were 4.90, 1.02, 28.08 and 6.42 mg./kg., respectively. The coefficients of variation were 12.0, 10.2, 10.4 and 13.8 percent, respectively.

A significant negative coefficient of correlation was found between the protein content and niacin content, but no correlation was found between the protein content or ether extract content and any of the B-vitamins, nor was any correlation found between any of the members of the B-vitamin complex.

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RATE, METHOD, AND DATE OF PLANTING CORN[1]

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DEPARTMENT OF FARM CROPS

THE EFFECTS of rate, method, and date of planting on corn production have been the subject of a number of investigations. Many of these studies, however, were conducted with open-pollinated varieties which have been replaced by hybrids with more desirable characteristics including a generally higher yielding ability. The change from open-pollinated to hybrid varieties makes necessary a re-examination of the recommendations based on experiments conducted largely with open-pollinated corn. Also, results of experiments conducted in neighboring states do not always apply to other states where the climate, soil conditions, and hybrids may give different results.

The purpose of this report is to present the results of rate, method, and date of planting of adapted corn hybrids on yield, ear weight, maturity, and lodging in Michigan.

MATERIALS AND METHODS

EXPERIMENTS IN 1947 AND 1948

Thirty-one commercially available hybrids were tested for their response to rate of planting in 1947 and 1948 at the Michigan Agricultural Experiment Station at East Lansing. Each hybrid was planted in hills spaced 42 by 42 inches at two rates of planting — two plants per hill (7,100 plants per acre) and three plants per hill (10,670 plants per acre). Three replications of each rate of planting were used for each hybrid; the plots were two rows wide and five hills long. The soil was a Conover loam, and alfalfa preceded the corn in both years.

EXPERIMENTS IN 1949 AND 1950

Rate of planting was investigated at five locations (Ingham, Saginaw, Monroe, Kalamazoo, and Newaygo Counties) in 1949 and at five locations (Ingham, Clinton, Saginaw, Monroe, and Kalamazoo

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Counties) in 1950. The Clinton County experiment was conducted on muck soil. Method of planting was combined with rate of planting in Monroe, Saginaw, and Ingham Counties in 1949 and 1950. In these experiments corn was either planted in hills or drilled in the row at three rates of planting. The Ingham County tests were repeated in both years on three different planting dates to study the effects of time of planting on the rate and method of planting.

Three or four hybrids were used at each location. There were four replications of each treatment combination at each location and each plot consisted of 10 hills or an equivalent area of land drill-planted. Each plot was two rows wide.

Four rates of planting (2, 3, 4, and 5 plants per hill) were side-dressed with 0, 60, 120, and 240 pounds of ammonium nitrate per acre at the last cultivation in 1950 in Ingham County. Michigan 350 (formerly Michigan Experimental 267), a new certified corn hybrid for central Michigan, was used for this experiment. Eight replications of the 16 treatments were planted in a split plot design on May 9. Plots were two rows wide and 10 hills long with spacing 40 by 40 inches. The soil was a Conover loam that had grown corn in 1948 and 1949.

In all experiments, an excess of seed was planted and the plots were thinned to the desired stand when the plants were 15 to 18 inches tall.

RESULTS AND DISCUSSION

RATE OF PLANTING 1947 AND 1948

Table 1 presents the results of the experiments conducted in Ingham County in 1947 and 1948. In 1947 the 31 hybrids averaged 27.3 percent more corn per acre when planted at a rate of three plants per hill (10,670 plants per acre) than when planted at a rate of two plants per hill (7,110 plants per acre). The smallest yield increase for an individual hybrid was 11.2 percent and the biggest increase was 39.8 percent. The average increase in yield for the same hybrids in 1948 was 23.5 percent, the increases ranging from 2.9 to 36.0 percent. For the two-year period, the average increase was 23.5 percent, the range being from 9.5 to 36.1 percent.

Analyses of variance showed that the interactions of hybrids x rates of planting were not significant. All hybrids gave higher yields when planted at three plants per hill. However, the results in Table

Table 1—Average yield in bushels of shelled corn at 15.5% moisture for 31 corn hybrids planted at two rates of planting in 1947 and 1948, Ingham County.

Hybrid	1947			1948			Two-year average percent increase
	Plants per hill		Percent increase	Plants per hill		Percent increase	
	Two	Three		Two	Three		
DeKalb 240	51.9	60.4	16.4	69.0	84.2	22.0	19.2
DeKalb 404A	54.6	70.9	29.8	54.7	59.4	8.6	19.2
Funks G12	54.7	69.3	26.6	74.7	82.7	10.7	18.7
Kingscrost D4	56.5	69.5	23.0	62.7	76.3	21.7	22.4
Kingscrost M2	48.6	65.2	34.2	60.9	82.8	36.0	35.1
Kingscrost KN 1	50.6	60.9	20.4	71.2	85.6	20.2	20.3
Kingscrost KO	53.4	61.2	14.6	62.9	74.6	18.6	16.6
Kingscrost KR 2	55.9	73.0	30.5	72.3	80.5	11.3	20.9
Kingscrost KS 2	35.1	48.6	38.5	65.5	86.6	32.2	35.4
Kingscrost KS 6	49.5	64.4	30.1	57.2	65.2	14.0	22.1
Master F 82	45.2	62.8	38.9	72.0	94.2	30.8	34.9
Michigan 20 D	50.4	67.6	34.1	65.0	81.0	24.6	29.4
Michigan 24 B	51.4	66.2	28.7	59.1	76.0	28.6	28.7
Michigan 29 D	51.8	70.3	35.7	65.8	72.2	9.7	22.7
Michigan 36 B	52.8	61.8	17.0	55.4	68.5	23.6	20.3
Nosco N 4	48.7	62.3	27.9	65.0	79.9	22.9	25.4
Nosco N 6	48.9	63.1	29.0	73.3	75.4	2.9	16.0
Ohio M 15	50.9	64.5	26.7	67.0	79.8	19.1	22.9
Pfister P.A.G. 56	49.9	65.4	31.0	72.3	91.3	26.3	28.7
Pfister P.A.G. 60	53.8	68.1	26.6	66.1	77.1	16.6	21.6
Pfister P.A.G. 274	54.7	64.5	17.9	65.7	77.2	17.5	17.7
Pioneer 342	49.9	69.8	39.8	63.0	83.4	32.4	36.1
Pioneer 349	57.3	71.4	24.6	69.9	81.5	16.6	20.6
Pioneer 359	49.0	59.8	22.0	62.0	74.6	20.3	21.2
Pioneer 373	52.4	73.2	39.6	72.9	91.8	25.9	32.8
Supercrost F 138	53.8	59.8	11.2	68.1	73.4	7.8	9.5
United U 26	49.0	58.3	19.0	75.6	87.0	15.1	17.1
United U 30	42.2	56.6	34.1	67.1	79.8	18.9	26.5
United U 32	41.2	56.5	37.1	74.3	85.5	15.1	26.1
Wolverine 55	49.1	62.6	27.5	57.2	72.1	26.0	26.8
Wolverine 66	47.8	60.0	25.5	70.5	80.5	13.6	19.6
Average	50.4	64.2	27.3	66.0	79.0	19.6	23.5
Range	35.1 to 57.3	48.6 to 73.2	11.2 to 39.8	54.7 to 75.6	65.2 to 94.2	2.9 to 36.0	9.5 to 36.1

1 show that some hybrids gave a greater increase in yield in response to increased rate of planting than others.

Correlation coefficients (Table 2) show that there was a slight tendency for the earlier hybrids to give a higher response to rate of planting in both years. The correlation was significant at the 5-percent level of probability in 1947 but not in 1948. Association of

maturity with response to rate of planting was too small for the investigators to conclude that early maturing hybrids generally responded more to increased rate of planting.

Table 2—Correlation coefficients

Character correlated	r
Percent increase in yield with moisture content at harvest. 1947.....	−0.370*
Percent increase in yield with moisture content at harvest. 1948.....	−0.228
Percent increase in yield with average yield in bushels. 1947.....	0.145
Percent increase in yield with average yield in bushels. 1948.....	0.057
Yield at two plants per hill with yield at three plants per hill. 1947 ..	0.553**
Yield at two plants per hill with yield at three plants per hill. 1948 ..	0.788**
Percent increase in 1947 with percent increase in 1948.....	0.366*

*Significant at 5-percent level of probability.
**Significant at 1-percent level of probability.

There was no association between the average yield of a hybrid and its response to rate of planting. Ability to give a larger response to increased rate of planting was not a general characteristic of either the high- or the low-yielding hybrids.

Hybrids that were high in yield when planted at two plants per hill were also high in yield when planted at three plants per hill. The correlations were highly significant in both years. Inherent yielding ability of a corn hybrid was a varietal characteristic that was independent of rate of planting.

Response to rate of planting for the 31 hybrids tended to be similar in both years, as measured by the significant correlation of 0.366. Hybrids that gave the biggest increase in yield in 1947 tended to give the biggest increase in 1948 indicating that the ability to give a larger response to increased rate of planting tended to be a varietal characteristic.

Maturity, as measured by moisture content of the ears at harvest time, was not significantly affected by the different rates of planting.

RATE AND METHOD OF PLANTING, 1949 AND 1950

Yield—Results of experiments in which rate of planting and method of planting were compared in 1949 and 1950 at several locations in Michigan are given in Table 3. Agronomic information pertaining to each experiment is presented in Table 4.

The drill method of planting was superior to hill planting in 79 out of 96 comparisons. The average increase in yield was 5.3 bushels per acre, or 7 percent, in favor of drill planting. Plots of both methods of planting received the same amount of cultivation so that the effect of better weed control was not measured with the hill planting. Weeds were not a problem in any of the tests.

Table 3—Average yields in bushels of shelled corn at 15.5 percent moisture for rate and method of planting experiments conducted in Kalamazoo, Monroe, Saginaw, Clinton, Newaygo, and Ingham Counties in 1949 and 1950

	Hill planted			Drill planted			
	Plants per acre			Plants per acre			
Kalamazoo County, 1949*							
Hybrid	7,110	10,670	14,225				
Ohio M15.....	32.9	43.2	50.4				
Michigan 24B..	39.7	44.4	43.8				
Michigan 29D .	39.4	43.8	44.2				
Pioneer 322....	42.2	44.0	52.1				
Average.....	38.6	43.8	47.6				
Percent increase.....		13.5	23.3				
Kalamazoo County, 1950†							
Hybrid	7,800	11,700	15,600				
Ohio M15.....	40.7	47.9	47.5				
Michigan 29D..	43.7	51.7	54.1				
Pioneer 322....	43.8	51.2	47.6				
Average.....	42.7	50.3	49.7				
Percent increase.....		17.8	16.3				
Monroe County, 1949†							
Hybrid	7,800	11,700	15,600	Average	7,800	11,700	15,600	Average
Ohio M15.....	66.1	78.8	89.8	78.2	59.3	77.9	90.0	75.7
Michigan 24B..	67.0	79.7	81.2	75.9	65.2	83.3	88.2	78.9
Michigan 29D..	63.6	78.7	85.9	76.0	62.6	79.1	89.4	77.1
Pioneer 322....	62.7	75.0	80.3	72.7	59.3	78.4	85.9	74.5
Average.....	64.8	78.0	84.3	75.7	61.6	79.7	88.4	76.5
Percent increase.....		20.3	30.0	.....	.....	29.3	43.5	.....

Table 3, Continued

	Hill planted				Drill planted			
	Plants per acre				Plants per acre			
Monroe County, 1950†								
Hybrid	7,800	11,700	15,600	Average	7,800	11,700	15,600	Average
Ohio M15.....	53.5	63.6	67.1	61.4	53.2	69.4	71.8	64.8
Michigan 29D..	58.9	64.3	70.9	64.7	59.3	63.5	65.3	62.7
Pioneer 322....	60.6	63.9	64.1	62.8	65.8	72.8	76.7	71.8
Average.....	57.7	63.9	67.3	63.0	59.4	68.5	71.3	66.4
Percent increase.....		10.7	16.6	.....	.....	15.3	20.0	.....
Saginaw County, 1949†								
Hybrid	8,300	12,450	16,600	Average	8,300	12,450	16,600	Average
Michigan 11A..	61.2	77.0	92.3	76.8	63.9	88.0	99.4	83.7
Michigan 51B..	66.5	80.7	93.4	80.2	71.9	94.5	115.6	94.0
Michigan 36B..	65.5	94.5	106.2	88.7	69.9	94.3	107.3	90.5
Ohio M15.....	73.9	94.8	111.9	93.6	80.1	105.9	120.8	102.2
Average.....	66.8	86.7	100.9	84.8	71.4	95.6	110.8	92.6
Percent increase.....		29.8	51.0	.....	.....	33.9	55.2	.....
Saginaw County, 1950‡								
Hybrid	8,300	12,450	16,600	Average	8,300	12,450	16,600	Average
Michigan 11A..	57.0	74.9	86.3	72.7	64.4	85.1	98.0	82.5
Michigan 51B..	62.7	81.8	88.2	77.6	66.4	91.0	97.9	85.1
Ohio M15.....	67.3	85.3	90.2	80.9	68.2	92.5	98.5	86.3
Average.....	62.3	80.7	88.2	77.1	66.3	89.5	98.0	84.6
Percent increase.....		29.5	41.6	.....	.....	35.0	47.8	.....
Clinton County M.S.C. Muck Experimental Farm, 1950§								
Hybrid	9,680	14,520	19,360					
Michigan 11A..	41.6	51.1	63.9					
Michigan 250...	50.0	59.0	64.7					
Michigan 51B..	34.5	53.2	56.1					
Michigan 350...	50.1	58.7	67.4					
Average.....	44.0	55.0	63.0					
Percent increase.....		26.1	43.2					

Table 3, Continued

	Hill planted			Drill planted			
	Plants per acre			Plants per acre			
Newaygo County, 1949*							
Hybrid	7,110	10,670	14,225				
Michigan 11A..	35.8	46.9	49.8				
Michigan 51B..	40.8	51.5	64.1				
Michigan 36B..	47.8	54.5	66.4				
Ohio M15.....	56.9	67.3	75.7				
Average.....	45.3	55.0	64.0				
Percent increase		21.4	41.2				
Ingham County, 1949—Planted May 5†							
Hybrid	7,800	11,700	15,600	Average	7,800	11,700	15,600	Average
Michigan 51B..	52.9	76.8	90.9	73.5	60.2	78.5	94.7	77.8
Ohio M15.....	69.4	82.1	100.3	83.9	75.6	91.7	104.8	90.7
Michigan 29D..	73.5	90.1	105.1	89.5	76.4	95.6	108.9	93.6
Average.....	65.3	83.0	98.7	82.3	70.7	88.6	102.8	87.4
Percent increase		27.1	51.2	.....	.....	25.3	45.5	.....
Ingham County, 1949—Planted May 24†							
Hybrid	7,800	11,700	15,600	Average	7,800	11,700	15,600	Average
Michigan 51B..	54.0	65.3	77.6	65.6	48.8	63.6	75.9	62.7
Ohio M15.....	63.4	81.7	104.7	83.3	68.6	79.5	89.4	79.2
Michigan 29D..	66.1	78.9	88.0	77.7	66.2	84.4	94.0	81.5
Average.....	61.2	75.3	90.1	75.5	61.2	75.8	86.4	74.5
Percent increase		23.0	47.2	.....	.....	23.9	41.2	.....
Ingham County, 1949—Planted June 11†							
Hybrid	7,800	11,700	15,600	Average	7,800	11,700	15,600	Average
Michigan 51B..	62.0	82.3	93.6	79.3	60.5	79.4	96.8	78.9
Ohio M15.....	68.1	86.4	94.1	82.9	71.9	89.2	100.3	87.1
Michigan 29D..	68.3	83.0	101.7	84.3	69.9	92.5	108.0	90.1
Average.....	66.1	83.9	96.4	82.2	67.4	87.0	101.7	85.4
Percent increase		26.9	45.8	.....	.....	29.1	50.8	.....

Table 3, Continued

	Hill planted				Drill planted			
	Plants per acre				Plants per acre			
Ingham County, 1950—Planted May 9†								
Hybrid	7,800	11,700	15,600	Average	7,800	11,700	15,600	Average
Michigan 51B..	52.0	63.6	75.9	63.9	57.7	76.5	87.7	74.0
Ohio M15.....	63.5	72.8	84.3	73.5	57.2	90.2	101.4	82.9
Michigan 29D..	65.4	87.0	99.2	83.9	65.7	95.1	107.5	89.4
Average.....	60.3	74.5	86.5	73.7	60.2	87.3	98.9	82.1
Percent increase.....		23.5	43.4	.....	.....	45.0	64.3	.....
Ingham County, 1950—Planted May 25†								
Hybrid	7,800	11,700	15,600	Average	7,800	11,700	15,600	Average
Michigan 51B..	45.0	57.0	66.5	56.2	51.5	69.0	80.1	66.9
Ohio M15.....	53.9	63.5	75.9	64.4	62.7	73.1	89.1	75.0
Michigan 29D..	57.0	78.7	90.2	75.3	62.8	84.5	97.2	81.5
Average.....	52.0	66.4	77.5	65.3	59.0	75.5	88.8	74.4
Percent increase.....		27.7	49.0	.....	.....	28.0	50.5	.....
Ingham County, 1950—Planted June 15†								
Hybrid	7,800	11,700	15,600	Average	7,800	11,700	15,600	Average
Michigan 51B..	27.5	37.8	48.6	37.9	33.8	50.3	64.7	49.6
Ohio M15.....	30.5	37.9	46.2	38.2	34.5	50.8	58.5	47.9
Michigan 29D..	32.3	38.3	45.1	38.6	39.0	56.1	60.2	51.8
Average.....	30.1	38.0	46.6	38.2	35.7	52.4	61.1	49.7
Percent increase.....		26.2	54.8	.....	.....	46.8	71.7	.....

*42-inch row spacing:
7,100 plants per acre = 2 plants per hill 42″ x 42″
10,670 plants per acre = 3 plants per hill 42″ x 42″
14,225 plants per acre = 4 plants per hill 42″ x 42″

†40-inch row spacing:
7,800 plants per acre = 2 plants per hill 40″ x 40″ or 1 plant drilled every 20″
11,700 plants per acre = 3 plants per hill 40″ x 40″ or 1 plant drilled every 13⅓″
15,600 plants per acre = 4 plants per hill 40″ x 40″ or 1 plant drilled every 10″

‡36-inch row spacing:
8,300 plants per care = 2 plants per hill 36″ x 42″ or 1 plant drilled every 21″
12,450 plants per acre = 3 plants per hill 36″ x 42″ or 1 plant drilled every 14″
16,600 plants per acre = 4 plants per hill 36″ x 42″ or 1 plant drilled every 10½″

§36-inch row spacing:
9,680 plants per acre = 2 plants per hill 36″ x 36″
14,520 plants per acre = 3 plants per hill 36″ x 36″
19,360 plants per acre = 4 plants per hill 36″ x 36″

Table 4—Agronomic information for rate and method of planting experiments in 1949 and 1950

County and year	Cooperator	Soil type	Previous crops	Fertilizer	Row spacing	Date planted	Date harvested
Kalamazoo, 1949	A. A. Zelt Schoolcraft	Fox	Clover sod	None	42″	May 25	Oct. 18
Kalamazoo, 1950	Harry Sweitzer Schoolcraft	Warsaw	Clover sod	None	40″	May 23	Oct. 30
Monroe, 1949	Mike Sacala Dundee	Brookston	Sweet clover	250 lb. 0-14-7 10 loads manure	40″	May 31	Oct. 25
Monroe, 1950	Mike Sacala Dundee	Brookston	Wheat	300 lb. 3-12-12	40″	May 27	Nov. 1
Saginaw, 1949	Walter Reinbold Reese	Brookston	Alfalfa bromegrass	None	36″	May 10	Oct. 4
Saginaw, 1950	Walter Reinbold Reese	Brookston	Beans	None	36″	May 12	Oct. 24
Clinton, 1950	Muck Farm Bath	Muck	Tomatoes	500 lb. 0-10-30	36″	June 6	Oct. 28
Newaygo, 1949	Henry Bode Fremont	Antrim	Alfalfa bromegrass	Manured	42″	May 17	Oct. 13
Ingham, 1949	M. S. C. East Lansing	Conover	Soybeans and rye green manure	200 lb. 4-16-8	40″	May 5, May 24, June 11	Sept. 30 Oct. 18 Nov. 5
Ingham, 1950	M. S. C. East Lansing	Conover	Soybeans and rye green manure	200 lb. 4-16-8	40″	May 9 May 25 June 15	Oct. 3 Oct. 19 Nov. 9

The majority of the corn in Michigan is drilled in the row. Drilled corn is easier to pick with mechanical harvesters than hilled corn since there is usually less plugging of the machine. On the basis of these experiments, there is no justification to plant corn in hills except where two-way cultivation to control weeds is important. Differences in yield between the two methods of planting were small but usually in favor of drill planting.

Analyses of variance showed that rate of planting had a greater effect on corn yields than method of planting. In 75 out of 79 comparisons (Table 3) the best yield was obtained at the highest rate of planting. The only experiment where the high rate of planting failed to provide an increase in average yield was in the Kalamazoo County test in 1950. Dry weather in August and September reduced corn yields in the Kalamazoo County experiments in both years. It is noteworthy that there was no significant depression in yield at the highest rate of planting.

By doubling the rate of planting, from two to four plants per hill or the equivalent drilled in the row, the average increase in yield was 39 percent, or 2.8 bushels per acre for each added 1,000 plants per acre, for all tests in both years. The average yield increased 25 percent, or 3.5 bushels per acre for each additional 1,000 plants, for all tests when the planting rate was raised from two to three plants per hill or the equivalent number of plants drilled in the row. When the planting rate was increased from three to four plants per hill or the equivalent in drilled rows, the average increase in yield was 11 percent or 2.0 bushels for each additional 1,000 plants. These averages represent 237 treatments with 948 plots in 10 experiments during the two-year period.

There was no consistent trend for the early hybrid to give a higher response to rate of planting than the later maturing hybrid. In Table 3, the hybrids are listed in the order of their maturity from early to late. Response to rate and method of planting were similar for all hybrids as indicated by the analyses of variance where interactions involving hybrids were not significant. Additional experiments with higher rates of planting than those used in these tests are needed to determine if the early maturing hybrids can be planted at higher rates than the full-season hybrids.

The usual recommendation for rate of planting corn on fertile soils in Michigan has been three kernels per hill or one kernel every 13 or

14 inches drilled in 40- or 42-inch rows. Inspection of a number of corn fields in Michigan in 1949 and 1950 revealed that the average stand was approximately one plant in every 16 inches of 40-inch rows. With conditions comparable to those under which these experiments were conducted, it seems that corn yields could be improved by increasing the rate of planting to four kernels per hill or one every 10 or 11 inches, drilled in the row. The soils used in these experiments were in a high state of fertility. Weather conditions in 1949 were ideal for good corn production, but were less favorable in 1950, although yields were generally good in all tests. Even with the dry conditions that existed in the Kalamazoo County tests, there was no case of appreciable reduction in yield with the high rate of planting.

Ear Weight—Highest yields were obtained when the average ear weight at harvest was between 0.4 and 0.5 pounds. Average ear weights ranged from 0.60 to 0.70 pound at harvest time for the low rate of planting, 0.5 to 0.6 pound for the intermediate rate of planting, and 0.4 to 0.5 for the high rate of planting. Ear weight decreased as the rate of planting increased in all of the experiments. Loss in ear weight was more than offset by the larger number of ears per acre so that the net result was a larger yield. Large ears are not necessarily an indication of high yields, but may indicate that the maximum yield has not been obtained.

Maturity—There was no evidence that rate or method of planting had any effect on maturity as indicated by moisture content of the ears at harvest.

Lodging—Rate and method of planting had no consistent effect on stalk lodging as measured by the percentage of plants broken below the ear at harvest. In 27 out of 79 comparisons, lodging tended to increase as the rate of planting increased, while in 52 comparisons there was no consistent trend. There was no consistent difference in lodging between drilled and hilled corn. Drilled corn lodged more than hilled corn at the same plant population per acre in 48 out of 96 comparisons; hilled corn lodged more in 45 comparisons; and there was no difference in three of the comparisons. The average amount of stalk breaking ranged from 4 to 10 percent for the 10 experiments. Different results might have been obtained had there been more stalk lodging.

EFFECT OF NITROGEN SIDE-DRESSING ON RESPONSE

Results of the experiment to determine the effect of nitrogen side-dressing on response to rate of planting are presented in Table 5.

Nitrogen side-dressing provided significant increases in yield on the Conover soil where corn was grown for the third successive year.

Table 5—Average yield, ear weight, moisture content, and stalk lodging for Michigan 350 at four rates of planting and four rates of nitrogen side-dressing applications. Ingham County, 1950

Number of plants per acre	Pounds of ammonium nitrate per acre				Ave.	Pounds of ammonium nitrate per acre				Ave.
	0	60	120	240		0	60	120	240	
	Yield per acre					Weight per ear in pounds				
7,800	66.3	68.7	69.3	72.2	68.9	0.73	0.78	0.77	0.80	0.78
Percent increase	.....	3.6	4.5	7.4						
11,700	81.5	85.6	88.9	89.5	86.4	0.62	0.65	0.66	0.67	0.65
Percent increase	.....	5.0	9.1	9.8	25.4					
15,600	80.7	99.7	100.0	95.9	94.1	0.48	0.57	0.57	0.55	0.54
Percent increase	.....	23.5	23.9	18.8	36.6					
19,500	82.8	100.4	108.9	104.3	99.1	0.38	0.46	0.49	0.48	0.45
Percent increase	.....	21.3	31.5	26.0	43.8					
Average	77.8	88.6	91.8	90.2	.....	0.56	0.62	0.62	0.63	.....
Percent increase	.....	13.9	18.0	15.9						
	Moisture in ears, percent					Stalk lodging, percent				
7,800	33.7	33.8	32.0	33.0	32.9	8.7	3.7	7.0	5.1	6.1
11,700	33.4	33.4	32.7	33.2	33.2	9.8	10.5	6.8	6.3	8.4
15,600	34.4	33.7	34.3	34.5	34.2	14.2	13.3	17.7	11.1	14.1
19,500	35.0	34.3	33.1	34.4	34.2	21.6	19.0	17.6	22.0	20.1
Average	33.9	33.8	33.0	33.8	.....	13.6	11.6	12.3	11.1	.....

Response to nitrogen side-dressing increased as the rate of planting increased. At the high rate of planting the yield increases for side-dressing were larger than at the lower rates of planting.

Average yields increased as the rate of planting increased. A plant population of 19,500 plants per acre (5 plants per hill) provided a significant average yield increase of 5 bushels per acre more than a population of 15,600 plants per acre (4 plants per hill). The highest yield was obtained with 5 plants per hill or 19,500 plants per acre

side-dressed with 120 pounds of ammonium nitrate per acre at the last cultivation.

Application of 240 pounds of ammonium nitrate per acre produced a significantly lower average yield than 120 pounds. The yield reduction with the high rate of side-dressing may have resulted from a situation where one or more of the other essential elements became limiting.

Moisture content of the ears at harvest (Table 5) showed that the nitrogen had no effect on maturity of the ears. Nitrogen side-dressing had no effect on lodging. In this experiment there was more stalk breakage at the higher rates of planting, but results of the experiments described previously showed that this condition did not exist at all locations.

Increasing the number of plants per acre reduced the ear weight, but the larger number of ears per acre more than made up for the smaller ear size. Nitrogen increased the ear weight at all rates of planting. Increase in ear weight due to nitrogen side-dressing was larger at the higher rates of planting.

There was a deficiency of nitrogen on the plots that received no side-dressing, as evidenced by plant symptoms. This deficiency was expected since this field was growing its third successive crop of corn.

DATE OF PLANTING, 1949 AND 1950

Date of planting was combined with rate and method of planting for three hybrids in Ingham County in 1949 and 1950 (Table 3). Analyses of variance showed that the yield response to rate and method of planting was not affected by date of planting in either of these two years. Regardless of date of planting, yields increased as the planting rate increased. Drilled corn tended to yield higher than hilled corn for all dates of planting.

In both years, yields were significantly better when corn was planted at the first date of planting (May 5, 1949 and May 9, 1950) than when planted at the usually recommended date (May 20-25) for central Michigan. Yields averaged 9.9 and 8.0 bushels more for early planting in 1949 and 1950, respectively (Table 6). Study of weather records for East Lansing shows that temperature and rainfall were more favorable for the early planting during the critical stage of plant development (two to three weeks following silking). Hot dry periods during silking and the following two or three weeks may reduce corn yields.

Table 6—Average yield, moisture, days to mid-silking, and stalk lodging for three hybrids planted at three dates in two years near East Lansing in Ingham County

Hybrid and date of planting	Bushels per acre at 15.5 percent moisture		Moisture in ears, percent		Days from planting to 50 percent silked		Stalk lodging, percent	
	1949	1950	1949	1950	1949	1950	1949	1950
*Michigan 51B	75.7	68.9	27.3	33.9	67	78	4.4	9.9
Ohio M15	87.3	78.2	31.6	38.7	76	87	3.8	3.9
Michigan 29D	91.6	86.6	34.1	41.0	80	89	3.0	5.3
Average	84.9	77.9	31.0	37.9	74	85	3.8	6.4
†Michigan 51B	64.2	61.5	28.7	32.2	61	71	6.9	17.5
Ohio M15	81.2	69.7	29.6	38.2	66	78	2.8	3.6
Michigan 29D	79.6	78.4	32.9	39.7	69	79	3.8	3.5
Average	75.0	69.9	30.4	36.7	65	76	4.5	8.2
‡Michigan 51B	79.1	43.8	26.9	42.4	53	69	19.3	22.7
Ohio M15	85.0	43.0	29.2	50.9	57	74	18.5	15.0
Michigan 29D	87.2	45.2	32.0	55.6	60	77	13.5	16.1
Average	83.8	44.0	29.4	49.7	57	73	17.1	18.0

1949	1950		1949	1950
*Planted—May 5	May 9		Harvested—Sept. 30	Oct. 3
†Planted—May 24	May 25		Harvested—Oct. 18	Oct. 19
‡Planted—June 11	June 15		Harvested—Nov. 5	Nov. 9

Light frosts with temperatures of 30, 31, and 31° F. occurred on May 25, 26, and 28, respectively, in 1949 after the first planting had emerged. The emerged seedling leaves were killed, but soil temperatures did not get low enough to kill the growing point of the seedlings. New growth was produced and the plants developed in a normal manner. These results emphasize that light frosts after corn has emerged may not be severe enough to kill the plants even though the above-ground seedling leaves may be killed. Under these circumstances it would be advantageous to wait several days to see if the plants will recover and produce new leaves before replanting the field.

Late planting, June 11, in 1949 gave as good yields as the early planting and was significantly better than the normal planting date, May 24. Cool weather during the latter part of the growing season and pre-mature killing frosts prevented full development of the late planting in 1950.

All plots for each date of planting were harvested approximately

147 days after planting. When harvested the same number of days after planting, there were no significant differences in moisture content among the dates of planting except for the late planting in 1950.

Evidence that the later plantings caught up, in part, in plant development and maturity with the early planting is shown by the number of days from planting to the average date when 50 percent of the plants were in silk. The number of days from planting to mid-silking decreased as the date of planting advanced (Table 6). There were 14-, 19-, and 20-day differences between the May 5 and June 11 plantings for Michigan 51B, Ohio M15, and Michigan 29D, respectively, in 1949. In 1950 the differences between the early and late planting were 9, 13, and 12 days for the three hybrids. It seems that plants of the later hybrids, Ohio M15 and Michigan 29D, were catching up in development faster than the early hybrid, Michigan 51B. Silking and maturity were 10 days to two weeks later in 1950.

Lodging was significantly greater in the late planting in both seasons, but there was no significant difference in lodging between the first two dates of planting. Where the corn-borer is a problem in corn production, early planting is not recommended since the moths usually prefer to lay their eggs on the taller corn.

Two years' results at one location are not enough to permit a general recommendation that early planting will give higher yields under all conditions.

SUMMARY

The effects of rate of planting corn on yield, ear weight, maturity, and stalk lodging were investigated in 13 experiments conducted at six locations during the four-year period, 1947 to 1950, with a number of hybrids. Effects of method of planting were studied in six experiments at three locations in 1949 and 1950. The effect of nitrogen side-dressing at the last cultivation was studied with four rates of planting in one experiment conducted on a Conover loam soil that was planted to corn for the third successive year. Two years' results on the effect of date of planting at one location are presented.

Thirty-one commercially available hybrids averaged 23.5 percent more corn per acre when planted at three plants per hill than at two plants per hill during 1947 and 1948. The smallest average increase was 9.5 percent, and the largest increase was 36.1 percent. Hybrids differed in their ability to respond to increased rate of planting. The ability to give a bigger response to increased planting rate was a

varietal characteristic that was not dependent on the maturity or yielding ability of the hybrid. The inherent ability of a hybrid to give high yields was a characteristic that was independent of the rate of planting.

Drilled corn averaged 5.3 bushels, or 7 percent, more corn per acre than corn planted in hills. The differences in yield were small but consistently in favor of drill planting.

Rate of planting had a greater effect on corn yields than method of planting. The average yield increased 25 percent for all tests in 1949 and 1950 when the planting rate was raised from two to three plants per hill or the equivalent number of plants drilled in the row. When the planting rate was increased from three to four plants per hill or the equivalent in drilled rows, the average increase was 11 percent. Doubling the rate of planting, from two to four plants per hill or the equivalent in drilled rows, increased the average yield 39 percent. The highest yield was obtained at the highest rate of planting in 75 out of 79 comparisons. There were no significant depressions in yield at the high rate of planting. The soils used in these experiments were in a high state of fertility, and the weather was generally favorable for good corn production.

Ear weight decreased as the rate of planting increased, but the loss in ear weight was more than offset by the larger number of ears per acre.

Maturity of the corn was not affected by rate or method of planting.

Rate and method of planting had no consistent effect on stalk lodging.

Response to nitrogen side-dressing increased as the rate of planting increased on a Conover loam soil that was planted to corn for the third successive year. Nitrogen side-dressing had no effect on maturity or lodging.

When light frosts occur in the spring of the year, the emerged seedling leaves of corn may be killed, but the soil temperature may not get low enough to kill the growing point of the seedling. Under those conditions it would be advantageous to wait several days to see if the plants will recover and produce new leaves before replanting the field.

Early planting gave the highest average yield in the two-year experiment conducted in Ingham County. Long-time data are needed to establish the optimum date of planting.

FATHER-AND-SON FARMING AGREEMENTS IN SOUTH CENTRAL MICHIGAN[1]

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INCREASED mechanization, larger farm units, and the problem of obtaining dependable farm labor have combined to develop a situation in which many fathers and sons are finding it mutually beneficial to pool their resources in the operation of a farm.

What are the conditions which contribute to the success of a father-and-son farm business operating agreement? Experience indicates that many of these working relationships are very successful. Others

Fig. 1. In successful farm partnerships father and son are able to get along well working together.

are very unsatisfactory. This report presents the results of a study of more than 50 successful father-and-son farm operating arrangements in south central Michigan.

[1]Digest of a M.S. thesis by author.

ARTICLE 33-50

The purposes of this study were to:

(1) Determine the nature of successful father-and-son farm-operating agreements in an effort to discover possible strong points and weaknesses.

(2) Develop ideas for improving father-and-son farm-operating agreements.

THE SAMPLE

Lists of names of fathers and sons who were working together successfully were supplied by county agricultural agents in south central Michigan. Seventy-five farms were visited and both fathers and sons interviewed. On 52 farms, a definite operating arrangement was found. Questionnaires were completed on these 52 farms and provide the information upon which this report is based. Information obtained on the remaining 23 farms was used to supplement the findings on the 52 farms with definite operating arrangements.

Information about arrangements which had failed was obtained only as it was uncovered in the regular interview. No attempt was made to study further the failures because of difficulties in obtaining complete and reliable information about them.

GENERAL INFORMATION

Of the 52 farm-operating agreements studied, over 90 percent were for farms where a father and one or more sons were working together. In two instances, a son-in-law and son were operating with the father. There was one case each of a father and son-in-law; grandfather and grandson; and a mother and son operating together. The fathers and sons had been working together under a definite arrangement for an average period of 6 years, with a range of from 1 to 17 years.

Fathers on these farms averaged 53 years and the sons 21 years old when they began definite business arrangements (Table 1). Ninety-five percent of the fathers were married and 5 percent were widowed. Thirty-one percent of the sons were married before the operating agreement began. Another 36 percent of the sons were married at an average of 3.3 years after the operating agreement was put into effect. About one-third of the sons were still single after having been in partnership an average of 4.5 years. The single sons ranged from 18 to 27 years old.

There was an average of 3.5 children in the father's family, two of whom were sons. On 38 percent of the farms the son was an only son. In 75 percent of the cases only one son was included in the agreement; in 21 percent, two sons; and in 4 percent of the agreements, three sons. The range in age between fathers and oldest sons, only sons, and youngest sons is shown in Table 1.

Table 1—Average age of father and son at the beginning of the farm-operating agreement

Son included in the farm operating agreement	Age at the beginning of the operating agreement	
	Father	Son
One son in agreement:*		
Oldest son	49.1	21.8
Only son	49.6	20.6
Youngest son	59.0	20.9
Average all farms	52.5	20.7

*Includes only cases where one son was in the farm business operating agreement with the father.

CHARACTERISTICS OF SUCCESSFUL OPERATING ARRANGEMENTS

ABILITY TO WORK TOGETHER

The ability to get along well and work together was mentioned first and most frequently by fathers and sons as a factor which contributed most to the success of the farm operating agreement. General agreement on farm-operating policy was reported by fathers and sons on over half the farms. Occasional differences were reported by 46 percent of the fathers and 34 percent of the sons. Frequent disagreement was reported by less than 2 percent of the fathers and sons. It was significant that on nearly two-thirds of the farms, fathers and sons answering separate questionnaires, gave identical answers to questions concerning their ability to agree. Eighty-two percent of the fathers and 72 percent of the sons reported that they generally agreed upon the kind and amount of equipment needed in the farm operations.

Applying the "Golden Rule" and "putting yourself in the other fellow's place" were mentioned frequently as important in father and son working relationships.

AN ADEQUATE SIZE OF BUSINESS

The importance of doing enough business to provide an adequate income for the father and son and their families was mentioned as a factor contributing to the success of their farm operating arrangements almost as often as the ability to get along well. In many instances, the size of business was increased at the time the father and son operating agreement was set up. Fifty-four percent added land, 42 percent added livestock, and 23 percent added both land and livestock. In 8 percent of the cases, the son replaced a hired hand.

On 82 percent of the farms, the fathers and sons believed that their business was large enough to support two families. Twelve percent would like a little larger business and 6 percent stated that their business was definitely too small.

Slightly more than 100 acres per man on these farms was providing both father and son and their families with a satisfactory standard of living (Table 2).

Table 2—Acres operated per man on farms with one, two, and three sons as compared with farms in type-of-farming Area 5, 1948-1949

Item	Number of sons participating			All farms in the study	Type of farming Area 5*
	1	2	3		
Number of farms	40	10	2	52	328
Man equivalent	2.1	3.2	4.0	2.4	1.7
Total acres:					
Per farm	251	341	420	275	220
Per man	120	107	105	114	129
Tillable acres:					
Per farm	199	283	365	220	166
Per man	95	88	96	93	98

*Michigan State College Farm Accounting Project cooperators in the general farming area of south central Michigan.

The number of acres per man tended to decline as the number of sons in the operating arrangement increased. As compared with the farm account cooperators in Area 5, the "father-son"-operated farms had 25 percent more land and carried about 26 percent more livestock. The account cooperators operated about 5 acres more tillable land per man than the fathers and sons.

One of the reasons given by both fathers and sons for operating together was that larger scale, more efficient operation was possible, justifying the ownership of larger pieces of equipment. All farmers used tractor power, and averaged two tractors per farm. As can be seen in Table 3, the ownership of labor saving equipment was quite common.

Table 3—Percent of farms using various machines in their farm operations

Machine	Percent using machine
Tractor	100
Milking machine	83
Combine	77
Truck or pickup	71
Corn picker	54
Elevator or grain blower	54
Forage harvester	37
Pickup baler	15
Gutter cleaners	4
Sugar beet harvester	4

INTEREST IN FARMING

Eighty percent of the sons in this study indicated that they were more interested in farming than any other occupation. The other 20 percent indicated that they believed they liked farming as well or better than any other occupation. Seventy-one percent of the sons' wives had been farm girls. In 73 percent of the cases studied, the sons indicated that their wives were very interested in the farm business. Twenty-seven percent were moderately interested. None indicated a complete lack of interest.

Fathers in general were interested in farming. A few fathers appeared to be interested in getting their sons to take over the farming operations so they would be relieved of the work and responsibility. A few fathers wanted the son to farm because they were interested in keeping the farm in the family.

SEPARATE HOUSING FOR EACH FAMILY

The farm families in this study were very much aware of the importance of providing separate housing for each family. In 95 per-

cent of the cases where the son was married, separate housing was provided for his family. The other 5 percent were situations in which a widowed father made his home with the son and his family.

Houses for both fathers and sons were modern. All homes had electricity. Piped running water was provided in 96 percent of the father's homes and in 93 percent of the sons' homes. Flush toilets had been installed in 90 percent of the father's homes and in 85 percent of the sons' homes.

A BELIEF THAT WORKING TOGETHER IS DESIRABLE

Both fathers and sons recognized the fact that they were mutually benefited by a father-and-son working arrangement. Over two-thirds of the fathers and sons said they were doing better farming together than they would be able to do individually. About one-third believed they were doing as well working together as they could do individually. None of the fathers and only 2 percent of the sons expressed a belief that they could do better operating individually than by working together.

Over three-fourths of the fathers reported that having a young man in the business helped greatly in keeping them stimulated and looking into the future. Ninety-eight percent of the sons reported that it was an advantage to be able to work with their fathers.

Ninety-seven percent of the sons indicated that if they were their fathers' age and had a son their age, they would like to have that son in business with them.

KNOWLEDGE OF THE BUSINESS BY THE SON

In 90 percent of the arrangements studied, fathers reported that their sons contributed greatly in planning and making decisions on the farm operations. On 10 percent of the farms, fathers reported some difficulty in getting their sons to assume responsibility. No father reported that his son wanted to make too many of the decisions.

Two-thirds of the fathers reported that their sons could manage the farm very well alone. One-third believed their sons would need some advice from them in carrying on the farm operations. The sons who were considered by their fathers as being able to take over the farm operations averaged about three years older than those sons whose fathers reported as still needing some advice and help.

On two-thirds of the farms, fathers rated their son's ability to manage the farm the same as the sons rated their own ability. Nearly one-

third of the fathers rated their sons' ability higher than the sons rated themselves. Only one son rated his ability above the rating given him by his father.

Experience in 4-H clubs, the Future Farmers of America and training in Michigan State College short courses were rated high by both fathers and sons as factors contributing to the success of their father-and-son farm business arrangements. Over 80 percent of the sons had 4-H club experience. Three-fourths had been in the F. F. A. Nearly one-half had completed eight weeks or more of short course work at Michigan State College. Over 30 percent of the sons had experience in 4-H clubs, F. F. A., and M. S. C. short courses. Many of the sons mentioned that it was through their 4-H club and F. F. A. projects that they became interested in farming and began to work with their fathers.

GOOD FARM MANAGEMENT APPLIED

Good farm management was evident on most of the farms included in this study. In addition to having between 90 and 100 tillable acres per man, these farms were well stocked with high-producing livestock. D. H. I. A. records were kept on over one-half of these farms. An average production of 368 pounds of butterfat per cow was reported. Although production records on poultry and hogs were not generally available, these enterprises were above average in size and seemed to be receiving the attention normally devoted to a major enterprise.

On farms in this study, an average of 108 pounds of commercial fertilizer was applied per tillable acre annually. An average of 20 acres of legumes were seeded annually as compared with 19.5 acres on accounting project farms in Area 5. Thirty-one percent of the tillable land was in hay and pasture compared with 38 percent on Area 5 farms. Crop yields per acre reported on these farms were equal to or slightly above average for Area 5 farms.

Some type of farm records was kept on all farms. Over one-fourth of the fathers still kept the farm records. On over one-fourth of these farms father and son shared the bookkeeping chores. On nearly 40 percent of the farms the son had assumed this responsibility. Either the mother or son's wife had assumed the responsibility for keeping books on about 6 percent of the father-and-son-operated farms.

PARTICIPATION IN THE ENTIRE BUSINESS

An arrangement permitting the son to share in the entire farm business seemed to have several advantages:

1) It gave the son an interest in all enterprises on the farm and helped him to develop an appreciation of the farm business as a whole.

2) It greatly simplified the problem of dividing items of income and expense, especially if the son had an interest in several enterprises.

3) It tended to give the son a more uniform income from year to year than would a single enterprise.

In a few cases in this study, the son was still in the transitional period between the enterprise project and full participation in the business. Keeping track of expenses and income from this arrangement proved difficult. On these farms, plans were being developed for the son to participate in the entire farm business.

THE OPERATING AGREEMENT

Farm business-operating arrangements were in written form in only 20 percent of the cases studied. The other 80 percent had only oral agreements. Many of these were indefinite and loosely formed.

There was considerable evidence that many of the agreements had been patterned after the plan proposed in Michigan Agricultural Experiment Station Special Bulletin 330, "Father and Son Farm Partnerships." About one-half were following this plan rather closely and showed a definite relationship between contributions made by father and son and the share of income each received. In the other half of the agreements studied, it was quite common for the father and son to each furnish all of some items and to share in part or all of the income from different enterprises, but not necessarily in the same proportion as expenses were shared.

In many instances where only oral agreements existed, and to some extent where written agreements were used, both father and son expressed a desire to improve their operating agreement. Most fathers seemed anxious to be fair with their sons but were not sure what might be considered a fair deal.

TENURE OF AGREEMENTS

Most father and son farm operating agreements continued from year to year, apparently with little thought given to terminating them. A few expressed hope that they would continue for many years.

These agreements seemed to be most satisfactory when: 1) the range in age between father and son was less than 30 years and 2)

during that period in which the father was young enough, and the son old enough, to participate actively in the operation of the farm business.

Fathers in this study averaged 53 and sons 21 years old at the beginning of the agreement. In ten years, these fathers will be 63 and their sons 31 years old. The operating agreement will have served its purpose during a 10- or 12-year period and may be replaced by a rental agreement or by the son taking over complete ownership. A father 46 and son 21 years of age should be able to work together actively for 20 years or more. A father 60 would be active for a much shorter period of time. Operating arrangements in this study where the father was over 65 years of age were not too satisfactory. The fathers were ultraconservative, and the span in years between father and son presented a real problem.

CONTRIBUTIONS BY EACH PARTY

Labor—The sons in this study contributed an average of 11.8 months of labor a year. The father averaged 11 months out of the year on the farm. A number of fathers spent some time in the south during the winter. A few had outside interests in the community which took them away from the farm. Several fathers and sons emphasized the importance of arranging for each to take a two weeks vacation during the year. An advantage of father and son working together is that it is possible for either father or son to have a day or weekend off occasionally and still have a responsible party on the farm to see that the work is done.

Land and Buildings—On the farms studied, all fathers owned land. Nearly one-third of the sons owned some land. Land rented to increase the size of business was in some cases rented by the father and son as partners or by the father or son individually.

The average acreage and percentage of owned, rented, and total land supplied by father and son for all farms in the study are shown in Table 4.

Many fathers not only contributed land and buildings but also paid taxes, insurance and repairs on the buildings. In many instances, they received no compensation for their greater contribution of real estate when settlement was made. A few fathers volunteered that the son had worked at home all his life and the addition of land and many improvements would not have been possible without his help.

Table 4—Average acreage and percentage of land supplied by fathers and sons on 52 South Central Michigan farms

Land supplied by	Owned Land		Rented Land		Total Land	
	Acres	Percent	Acres	Percent	Acres	Percent
Father	177	82	28	47	205	74
Son	38	18	32	53	70	26
Total farm	215	100	60	100	275	100

Another factor taken into consideration was that the father's labor contribution was less than the son's either because of fewer days work on the farm or less physical strength.

Personal Property—The ownership of personal property by father and son was much more nearly in proportion to division of income than was real estate. A one-half interest in personal property by the son was most common when there was one son in the operating agreement. Where two sons were in partnership with their father, each son frequently owned one-third or one-fourth of the personal property (Table 5).

Table 5—Percentage of sons owning various shares of the personal property

Share	Percentage of sons owning
Over one-half	5
One-half	37
One-third	15
One-fourth	14
Less than one-fourth	15
Other shares	14

In about 12 percent of the cases studied, fathers still retained full ownership of the machinery and equipment. Father and son were sharing machinery and equipment in some definite proportion on 77 percent of the farms. In 11 percent of the situations, the father furnished certain machines and the son furnished others. Each received the trade-in value of his own machinery.

DIVISION OF INCOME

The most common practice followed in dividing income and expenses was for the father and son each to pay a set share of the farm-operating expenses — for example: one-half, one-third, and one-fourth and then to share in the income in the same proportion.

A 50-50 division of farm-operating expense was most common where father-and-son shared about equally in ownership of farm personal property. When two sons were included in the operating agreement, the division was usually either ⅓-⅓-⅓, or ½-¼-¼, with each son in the latter case paying 25 percent of the expenses and receiving 25 percent of the income. Ownership of personal property in each case was in the same proportion as the division of income.

Although most of the farm expenses and income on many farms were shared as suggested in the Michigan Father and Son Farm Partnership Plan, by Prof. E. B. Hill, there were often specific items of expense which the father accepted as his obligation. For example, 46 percent of the fathers paid all items of building insurance and repair. On 40 percent of those farms, the father reported that he paid all the taxes.

The division of farm income and expenses on farms in this study is further illustrated in Table 6.

Complete and accurate farm records are necessary if a proper division of income and expenses is to be made. When farm accounts are lacking, receipts and expenses are often divided as they occur. This involves many transactions and results in few, if any, records being kept of income and expenses.

HANDLING FINANCES

In the father-and-son agreements studied, it was found that fathers and sons cooperated very well in the problem of handling finances. In 65 percent of the cases studied, finances were handled by father and son together; that is, either or both handled transactions. In 21 percent, the fathers still handled all finances. In 14 percent, the sons had taken over completely the handling of finances.

Forty-three percent divided income and paid expenses as they occurred. Others used the once a week, once each month, or a combination of methods. It was apparent that some did not have much of any system.

Table 6—Percentage of fathers paying and/or receiving different portions of items of expenses and receipts

Item	Share of expenses paid and/or income received by father					
	None	One-fourth	One-third	One-half	Two-thirds	All
Expenses:	*Percent of fathers paying above shares**					
Building maintenance repair and insurance	4	2	10	19	6	46
Machinery purchases	15	2	12	38	4	12
Machinery operation and repair	8	2	10	46	10	13
Taxes	4	2	8	21	8	40
Livestock purchases	2	2	10	48	10	10
Feed expense	4	2	10	52	12	12
Livestock expense	4	2	10	48	12	12
Crop expense	4	2	10	50	10	13
Hired labor	12	2	10	44	8	13
Miscellaneous	4	2	10	54	10	12
Receipts:	*Percent of fathers receiving above shares**					
Cattle sales	2	2	10	48	10	10
Dairy product sales	4	4	8	50	12	2
Hog sales	2	2	7	51	15	5
Sheep and wool sales	0	3	10	51	13	6
Poultry sales	2	2	7	45	10	19
Egg sales	5	2	7	43	10	19
Crop sales	0	4	10	48	12	2
Machinery traded-in	15	2	12	38	4	12
Labor off the farm	10	2	12	43	12	7
Miscellaneous income	6	3	11	50	8	8

*Percentages do not equal 100 as less important arrangements are not included.

In 92 percent of the cases studied, cash for current living expenses came from a division of the milk check and egg sales, or in weekly or monthly settlements. Only 8 percent of the families received a specified amount of cash each week or month for current living expenses.

CAPITAL ACCUMULATION

Several methods or combination of methods were used by sons in acquiring an interest in the farm business:

1) Most sons had some savings and some livestock and equipment accumulated in 4-H club or vocational agricultural projects. This was applied as a part payment for a share in the farm personal property.

2) Some sons received a share in the increase of livestock and paid for their share of new equipment purchased. By this process the son had a limited cash outlay at the beginning of the agreement and gradually grew into the business.

3) In some instances the son borrowed enough to purchase his interest in the personal property and paid off the debt from his share of the farm income. Some fathers took the son's note for an amount necessary to give the son his share in the personal property. The son was then required to make regular payments of interest on the principal to the father just as he would to anyone outside the family.

4) The father made an outright gift of an interest in the personal property to the son. In a few instances, it was simply assumed that the son held an interest in the personal property and income was divided on that basis.

VARIATION IN HATCHING POWER BETWEEN STRAINS OF THE DARK CORNISH AND THE SINGLE COMB WHITE LEGHORN BREEDS

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REPORTS of the hatching power of the Dark Cornish breed are relatively scarce. Adverse impressions of the hatching possibilities of the breed are apparent. Landauer (1935) reported a lethal mutation in Cornish which had a shortening effect on the long bones and affected hatchability adversely. Henderson (1930) found no evidences of embryonic abnormality in a heterogeneous population of Dark Cornish during a study of embryonic growth rates.

Reports of the hatching power of White Leghorns are plentiful, and there is a general belief among poultrymen that Leghorns hatch better than Cornish. The Leghorn breed was chosen for comparison with the Dark Cornish because it is well known and its hatching power has been well established. Another reason for the comparison of the Cornish and the Leghorn is that extensive reciprocal crosses have been made between these two specific populations at this Station.

Hatchability is not necessarily a breed characteristic because there is considerable variability within breeds in this respect. Embryonic lethals which are bars to hatching have been found in several breeds other than the Dark Cornish. Landauer's extensive review (1948) is available and it is therefore unnecessary to recapitulate.

OBJECTIVE

The objective of the study described herewith was to compare the hatching performance of a sample of a population of Dark Cornish chickens with a sample of White Leghorns. The data are summarized in Table 1.

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Table 1—Comparison of hatchability† between Dark Cornish and White Leghorns

Line No.	Number dams	Fertile eggs	Average percent hatched‡,§
Dark Cornish Hens¶			
1	14	197	79**
2	13	254	88
3	16	266	86
Totals	43	717	85**
White Leghorns			
1	11	172	91
2	11	142	94*
3	6	81	91
Totals	28	395	92**
All dams	71	1,112	88

†Percentage of fertile eggs hatched.

‡Most sets were not candled until the 18th day as routine procedure. An unknown percentage (5-10 percent perhaps) of early dead embryos could have been classified as infertile.

§This average is the average of the percentage hatch of the individual dams rounded to the nearest whole number.

¶In 1948 a random sample of 180 pullet eggs from this Michigan State College strain after shipment to the Louisiana Experiment Station in 1948, hatched at the rate of 79.4 percent of all eggs set (none infertile) according to letter and records from Dr. C. W. Upp filed April 12, 1948.

**Deviation statistically significant at the 1-percent point by the X^2 test—"Expected" 88 percent. (Snedecor's [1937] tables.)

*Deviation statistically significant at the 5-percent point by the X^2 test—"Expected" 88 percent. (Snedecor's [1937] tables.)

RESULTS

It is apparent in Table 1 that the hatching percentage of the Dark Cornish hens is below that of the White Leghorns by 7 percent. Most of the variation from the average can be noted in line 1 (Dark Cornish) which concerns eggs that hatched 9 percent below the average of 88 percent. The significance of the difference was determined by the X^2 test. The data may be used to illustrate how different methods of statistical treatment may lead to different conclusions. If X^2 is cal-

culated from the pooled numbers of eggs in the two breeds, a value of 5.38 is obtained which is not significant. If the X^2 values are calculated for the separate lines a total value of 16.8 is obtained which is highly significant. Further examination of the data discloses that over two-thirds of the total value of X^2 is contributed by line 1. When line 1 is omitted, the X^2 value is reduced to 6.6 which is less significant, but it still indicates that the two populations differ with respect to hatching power.

CIRCUMSTANCES INCIDENT TO ACCUMULATION OF DATA

The circumstances under which the foregoing data were accumulated were approximately as follows:

GENETIC

The stocks consisted of descendants of approximately three lines each of Dark Cornish and White Leghorns. The stocks are maintained primarily for a general project entitled "The Inheritance of Meat Type". Their origin has been described by Henderson (1947), (1949) and (1950). Each line is more or less objectively inbred—the Cornish for better egg production and the Leghorns for better meat type. Selection for high hatching power has been necessarily incidental, and compromises of hatchability with the primary objective have been necessary at times because of the small population from which to select.

Age of Parent Stock—All of the dams which produced the eggs and most of the sires in each line were over one year old in the 1950 season. No attempt was made to segregate the yearling from the two-year-old hens or sires in the limited samples because most of the pens contained comparable ages. Landauer (1948) compiled data from several different reports which indicate an average decline in hatching power with age of roughly five percent per year.

Antecedent Egg Production—The possible variable influence of antecedent egg production was presumably equalized to some extent by allowing the hens to moult naturally at the end of the 1949 laying season after which a 13-hour light day was provided for all pens simultaneously and continued throughout the 1950 season.

ENVIRONMENTAL

Housing—An attempt was made to equalize the environment of all pens. Housing, lighting, heating, ventilating and other equipment including litter were as nearly identical as practicable for each pen. The pens were located in the east side of a long community laying house.

Feed—All pens were provided with the same standard Michigan State College feed mixture, oyster shell and water, so that they had equal opportunities at least to assimilate all the known and unknown nutritional factors possible when confined continually indoors. Feed was provided in the form of a "breeder" mash[2] which presumably contained all the currently postulated nutritional factors. A grain mixture (corn, wheat and oats) was fed in a wheat-straw litter each evening in an amount approximately equal to twice the amount of mash consumed daily[3]. There is no way of knowing just what the diet of each individual hen may be under this traditional feeding system, as pointed out by Henderson (1939), but it is still assumed to be standard by many experimenters.

Hatching Season—The hatching season from which the data were compiled extended from January 25 to April 11[4]. Seasonal variations may exist to some extent in these data but they are not prominent. Possible seasonal variation is thought nullified by the methods of pen management. All the birds were kept indoors continuously on concrete floors from the time they were first housed as pullets in the fall and for the balance of their life times. Auxiliary heat was used in the laying house to keep the temperature above 40-45° F. in winter for all pens. Windows are the same size and type in each pen. The glass is of the ordinary type which presumably filters out nearly all ultraviolet light.

METHOD OF DETERMINING AVERAGES

The averages of the individual dams for determining pen and breed average hatching power are presented in Table 1. This method of describing hatching power is assumed to be more appropriate when the X^2 test for significance is used to avoid bias. Pen and breed aver-

[2]Mash formula compiled by Dr. A. C. Groschke, Associate Professor of Poultry Husbandry.

[3]The popularly recommended ratio is equal parts of grain to mash but it is doubtful whether the individual hens adhere to the recommendation.

[4]Mr. Maurice Armstrong, Technician of Poultry Husbandry Department, was responsible for the operation of the incubators.

ages based on the percentage hatch of total eggs set may be biased significantly by disproportionate numbers of eggs from hens or pens which differ radically from the average. Whether the breed average should be determined by the average of the pen averages is debatable. It seems logical that the dam has more opportunity to influence the hatching power of the individual embryos than their sire simply because the dam contributes nearly all of the food material including the shell of the egg. Conclusive research evidence of Xenia in hatchability is lacking up to date. It seems reasonable that Xenia exists, because of the chromosomal contributions of the sire and the existence of known genetic embryonic lethals. Pen averages in these data are attributed to inherent breed capabilities, because the sires were from the same general ancestry as the dams.

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ELECTRIC COOLERS FOR MAINTENANCE OF CREAM QUALITY ON THE FARM

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THE production of good quality cream on the farm requires the observance of the proper sanitary practices in handling the cream and storing it at a temperature of 40° to 48° F. In order to provide these temperatures for holding cream on the farm, a low-cost mechanical cream cooler has been developed and built at Michigan State College (Fig. 1), through a grant-in-aid from Swift and Company. A Michigan refrigerator manufacturer is also interested in the problem and has recently built an experimental cream cooler employing the basic principles of the Michigan State College experimental cooler.

The principle of the cream cooler is the same as that of a milk cooler or a household refrigerator, namely, a dry-box type of cooling chamber in which cans of cream may be cooled and stored. Since the volume of cream cooled is much less than the volume of milk, the cream cooler may be smaller in size and in refrigeration capacity than a milk cooler. Because cream does not need to be cooled as rapidly as milk, the cooler can be of the dry-box type instead of having water surrounding the cans or using a cold water spray, as often employed in milk coolers.

The cooler built by Michigan State College was tested in the Agricultural Engineering laboratories and on a farm near East Lansing. These tests showed excellent results in maintaining the quality of cream (1).

In order to test the performance of cream coolers of this type in warmer climates, this cooler and the one built by the refrigerator manufacturer were placed on farms near Evansville, Indiana, and regular tests made from August to November, 1950. The objects of these tests were to a) determine the effect on the quality of the cream; b) determine the cost of operation; and c) determine the general practicability of this type cooler under farm conditions.

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TEMPERATURE DATA

Outdoor air temperatures during the tests were considerably higher than those found in Michigan. The average temperatures at Evansville during August, September, October, and November were 72.0°, 67.2°, 62.6° and 40.1° F., respectively. The normal average monthly

Fig. 1. Michigan State dry-box type cream cooler.

temperatures at Lansing for the same period are 69.3°, 61.7°, 50.3° and 37.2° F., respectively. Temperatures at Evansville were below normal for the months of August, September and November, and above normal during October. Milkhouse temperatures where the

cooler was located ranged from 80° to 90° F. maximum during the day.

METHOD OF CONDUCTING TESTS

In these tests, the farmer placed about one-half of the cream from each milking in the cooler, while the remainder of the cream was kept without refrigeration in the usual manner. Cooler "A" was placed in the pantry adjoining the farm kitchen. The cream that was not cooled was kept in the basement. Cooler "B" was placed in an uninsulated, cement block milkhouse. The uncooled cream was kept in a can near the tank of the water system which was also housed in the milkhouse. In most of the tests, the holding period for the cream was 4 days, although some cream held for 3 and 7 days was also tested. Acidity tests were conducted in the College creamery laboratory. The cream was also scored on the basis of the score of the butter that could be made from the cream.

RESULTS

The results of the tests are given in Tables 1 and 2. Note such items as cream acidity, cream quality, and electric energy consumption.

It is of note that with both coolers, without exception, the portion of the cream which was cooled was consistently lower in acidity and of better quality than the check portion. With cooler "A" the average acidity for the cooled batches was 0.206, as compared with 0.428 for that which was held by normal farm methods. With cooler "B", a similar pattern of results was noted, with the cooled batches averaging 0.265 and the uncooled, 0.572 acidity.

In some areas, the acidity test is used as a basis for grading cream. When the acidity is higher than a definite percentage, the cream is classed as second grade. This upper limit of acidity varies with localities but is usually 0.5 percent or lower(2).

The farmer who used cooler "B" had a "yeasty cream" problem before using the cooler. He felt that a cooler would be well worth the money in correcting this condition. As shown by the data, the use of the coolers greatly improved the quality of the cream.

Table 1—Results of tests made on cream stored in cooler "A" or in farmhouse basement

Wt. cream not cooled, pounds	Wt. cream cooled, pounds	Date of collection	Date of test	Acidity	Quality Score
	26½	8/17	8/17	0.17%*	90
20	.....	8/17	8/17	.50%	89
	53	8/24	8/24	.31%*	90
54	.....	8/24	8/24	.52%	89
	47	9/5	9/5	.28%*	90
38	.....	9/5	9/5	.56%	89
	31	9/8	9/8	.19%*†	90
27	.....	9/8	9/8	.39%†	90
	20	9/12	9/12	.21%*	90
25	.....	9/12	9/12	.41%	89
	15½	9/15	9/15	.27%*†	90
16	.....	9/15	9/15	.44%†	89
	16½	9/26	9/26	.15%*	91
18	.....	9/26	9/26	.40%	89†
	11	9/29	9/29	.21%*†	90†
12½	.....	9/29	9/29	.48%†	89
	19	10/3	10/3	.27%*	90
12	.....	10/3	10/3	.42%	89
	14	10/6	10/6	.17%*†	91
16½	.....	10/6	10/6	.30%†	90
	15	10/27	10/27	.12%*	91
17	.....	10/27	10/27	.32%	90
	18	11/2	11/2	.12%*	91
14½	.....	11/2	11/2	.39%	90
Average 22.6	.....	.....	.....	0.428%	90.4
	24.9	.....	.....	0.206%	89.4

Meter Reading August 8, 1950—9,754 kwh; Meter Reading November 2, 1950—9,803 kwh. Electrical Energy Consumption—49 kwh in 12.3 weeks or 3.98 kwh per week.

*This cream cooled in mechanical cooler.

†These samples were held for 3 days before delivery and others were all held for 4 days.

Cream Cooler "A" has a capacity of one 10-gallon can or three 5-gallon "shot gun cans". The cream in this experiment was held in a 10-gallon milk can.

COST OF OPERATION

The cost of operation of the coolers will vary with the local cost of power. However, during these tests, cooler "B", which cooled an average of 60.2 pounds of cream per test, consumed an average of 20.3 kwh. per week during the months of August and September. Cooler "A", cooling an average of 24.9 pounds per test, used an average of 4.6 kwh. per week during the same period. The operating cost as well as the initial cost could possibly be paid for by additional income from premiums paid for high quality cream and from reduced cream losses. At the present time few creameries pay a premium for

Table 2—Results of tests made on cream stored in cooler "B" or in milkhouse

Wt. cream not cooled, pounds	Wt. cream cooled, pounds	Date of collection	Date of test	Acidity	Quality score
70	.....	8/13	8/14	0.76%	89
	73	8/13	8/14	.24%*	90
	76	8/21	8/21	.27%*	90
70	.....	8/21	8/21	.53%	89
	75	8/31	8/31	.32%*	90
77	.....	8/31	8/31	.62%	89
	71	9/7	9/8	.29%*	90
64	.....	9/7	9/8	.57%	89
	47	9/13	9/14	.24%*	90
50	.....	9/13	9/14	.55%	89
	54	9/20	9/21	.21%*	90
40	.....	9/20	9/21	.45%	89
	44	9/27	9 28	.27%*	90
49	.....	9/27	9/28	.48%	89
	38	10/2	10/2	.30%*†	90
42	.....	10/2	10/2	.50%†	89
	41	10/9	10/9	.17%*	91
47	.....	10/9	10/9	.67%	89
	67	10/12	10/13	.31%*†‡	90
64	.....	10/12	10/13	.64% †‡	89
	63½	10/24	10/24	.23%*†‡	90
58	.....	10/24	10/24	.53% †‡	89
	73	11/13	11/15	.33%*†‡	90
69	.....	11/13	11/15	.56% †‡	89
Average 58.3	.....	.....	.....	0.572%	89.0
	60.2	.....	.....	0.265%	90.1

Meter Reading August 8, 1950—2,511 kwh; Meter Reading November 13, 1950—2,752 kwh. Electrical Energy Consumption 241 kwh in 14 weeks or 17.2 kwh per week.

*This cream was cooled in the mechanical cooler.

†All samples were held for 4 days before delivery, except those marked (†) which were held for 3 days, and those marked (‡) which were held for 7 days.

Cooler "B" was different from cooler "A" in that it used a fan to circulate cold air around the cans at all times. This cooler holds two 10-gallon milk cans and it was operated at this capacity during the experiment.

sweet cream, however. A premium could be paid if, by means of a cream cooler, the farmer could be certain of being able to deliver sweet cream. Most creameries do refuse cream which has a high acidity or mold content. The use of a cream cooler would eliminate this loss to the farmer.

The excellent results obtained by the use of these cream coolers has stimulated interest among manufacturers in developing and manufacturing this piece of equipment for the use of the farmer.

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ZINC PHOSPHIDE: ITS TOXICITY TO PHEASANTS AND EFFECT OF WEATHERING UPON ITS TOXICITY TO MICE

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THE control of meadow mice[1] in orchards by mechanically distributed cracked corn bait carrying about 2-percent zinc phosphide has been described (5). The method is being used in Michigan and has certain practical advantages (10). Use of poisoned grain in this manner raises the question of possible hazard to pheasants and to other ground-feeding birds. Two phases of this question are reported upon here: the acute toxicity to pheasants, and the effect of weathering upon the toxicity of prepared bait as tested against laboratory mice[2].

TOXICITY TO PHEASANTS

There are numerous reports concerning the high toxicity of zinc phosphide to poultry. Most of these accounts concern accidental poisoning of chickens following use of zinc phosphide in rat control (3, 9, 12). Sassenhoff (13, not available in the original) told of losses of poultry and game birds following use of zinc-phosphide-poisoned grain for destruction of field mice. In experimental determinations of the toxicity of zinc phosphide to chickens, Blaxland and Gordon (2) reported a median lethal dose of 20-30 milligrams per kilogram of body weight while Robertson, Campbell and Graves (11) observed the "lethal amount" to be between 7 and 17 milligrams per kilogram, based upon 25 fowls. Experimental data in this last paper allow estimation of the median lethal dose as 10 milligrams per kilogram, according to the methods of Finney (7).

The work reported here on the toxicity of zinc phosphide to pheasants was carried out at the bird sanctuary of the Kellogg Station of Michigan State College near Augusta, Michigan, between October 25 and November 6, 1949. Cages were placed in a secluded area where the half-wild birds were visited only when necessary. The pheasants[3]

[1] *Microtus pennsylvanicus* Ord.
[2] *Mus musculus* Linnaeus.
[3] *Phasianus colchicus* Linnaeus.

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used, eight females and eight males, were obtained from the game farm of the Michigan Department of Conservation. The birds were from the early hatch of the same year and thus corresponded in age to those birds which constitute the largest part of the wild population in the fall of any year, when mice are ordinarily poisoned in orchards. These birds were in apparent good health, and there was no reason to suspect any other causes for death except the poison used.

The experimental procedure was to place the birds to be tested in a cage with water but with no food at about dusk of one day and then to administer the dose of poison at about 9 the next morning, placing the bird immediately afterward in a cage with both food and water. The doses of zinc phosphide were administered in previously prepared small gelatin capsules (No. 5 size) which were thrust by forceps down the bird's throat. The poison used was labeled "8852 Zinc Phosphide Mallinckrodt, Control VJM."

The exact interval from receipt of dose to death of the bird is not known in most instances, since the birds were visited only a few times each day. The known limits of the times until death, as stated in Table 1, ranged from 3 hours to over 28 hours.

The data in Table 1 allow calculation, by methods outlined by Finney (7), of the median lethal dose as 8.8 milligrams per kilogram,

Table 1—Weights, doses, and times until death of game-farm pheasants given zinc phosphide in gelatin capsules by mouth, October 26—November 6, 1949

Females			Males		
Weight, in grams	Dose, in milligrams per kilogram	Time to death, in hours	Weight, in grams	Dose, in milligrams per kilogram	Time to death, in hours
700	60	2—3	1300	19	28—32
800	19	11—22	1400	15	survived
900	15	10—12	1400	15	1—26
825	15	1—26	1350	12	24—50
725	12	survived	1300	12	22—23
775	9	10—22	1375	9	10—22
800*	9	survived	1450	7	1—26
900	7	survived	1350	7	survived
850*	5	survived			

*The same bird, tested at the lower dose 9 days before the higher dose.

Log median lethal dose ± standard error = 0.946 ± .100

with an error of determination such that this value would be expected to lie between 6 and 14 milligrams per kilogram in 95 percent of similar determinations. Subject to considerably greater error, one may estimate that 95 percent of the pheasants would be killed by a dose of 22 milligrams per kilogram.

This determination of median lethal dose was carried out with zinc phosphide unaccompanied by food, using birds which had been starved in a uniform manner. To test roughly whether the presence of grain would cause any great reduction in toxicity, two of the surviving birds were force-fed small weighed amounts of prepared cracked corn bait which carried 2 percent of zinc phosphide, prepared in the manner usual for orchard use (10). Both of these pheasants died. One was a male bird which received 1.8 grams of bait and the other was a female which received 0.9 gram of bait. The calculated zinc-phosphide content of these two doses was 24 and 22 milligrams per kilogram, respectively. This dose level was approximately that computed as lethal to 95 percent of the birds ingesting it, and the death of these birds showed only that the cracked corn accompanying the poison did not change the toxicity in a major fashion.

These experiments showed that zinc phosphide is highly toxic to pheasants, with a calculated median lethal dose of approximately 9 milligrams per kilogram of body weight.

EFFECT OF WEATHERING UPON TOXICITY OF ZINC PHOSPHIDE

The toxicity of baits prepared with zinc phosphide is reported to deteriorate under weathering. Garlough and Spencer (8) stated, "Most phosphide compounds deteriorate rapidly on exposure to air, but this one retains its toxicity for three weeks or more after exposure on dry bait material. On moist bait it loses its toxicity more rapidly, but even so, its toxic period is sufficiently long to make the bait effective." Doty (4), using rolled oats with zinc phosphide in rat control in Hawaiian sugar-cane plantations, reported, "Wet baits made with zinc phosphide will deteriorate rapidly and soon become non-poisonous. Dry baits exposed to rain will also lose their effectiveness rapidly. This is an advantage in livestock areas because any old zinc phosphide bait accidentally left in the field will be less dangerous to stock as it ages. However, it is doubtful if the zinc phosphide will deteriorate any faster than the oats will sour or mold from moisture alone."

The chemical stability of poisoned bait prepared with zinc phosphide was investigated by Elmore and Roth (6) in California. Poisoned grain kept in a burlap bag in ordinary storage maintained a constant zinc-phosphide content as revealed by periodic analyses throughout the 180-day experiment. A sample of grain, containing 0.50 percent, was exposed to outdoor conditions but protected from rains. Analysis showed the zinc-phosphide content after one month to be 0.47 percent and after nine months to be 0.40 percent. In contrast, the analyzed content of zinc phosphide in a bait scattered in a field was reduced after two days of exposure to heavy rains from an original analysis of 0.21 percent to 0.14 percent of zinc phosphide. Another sample of poisoned grain, exposed to the weather on a roof, showed a decrease during the course of 29 days from an analyzed content of 0.56 percent zinc phosphide to 0.40 percent. During this time, rain fell two days, and the grain was subjected to considerable wind and dust. The authors considered that the diminishing content of poison might have been due to mechanical factors rather than to decomposition. They concluded from these experiments that there was practically no chemical change in storage of zinc-phosphide-poisoned grain but that "in field use some deterioration of baits may be expected, the rate depending chiefly on mechanical factors of rains and winds." All of their chemical determinations seem to have been for phosphide phosphorus content of the poisoned grain.

The question of whether weathering of zinc-phosphide-poisoned grain bait results in a relatively non-toxic end product within a short time is an important aspect of the use of such poisoned bait in Michigan orchards. The possibility of poisoning desirable birds or animals depends both upon the original toxicity of the grain, and upon the length of time the bait remains toxic and available to the animals. On the other hand, the effectiveness of a poisoned bait against mice in an orchard may depend partly upon the bait's remaining toxic long enough at least to deal with animals invading the area immediately after the eradication of the local population. It seemed desirable, therefore, to investigate the rate of deterioration in toxicity of zinc-phosphide-poisoned grain bait under conditions found in Michigan orchards.

Weather conditions vary during late fall and early winter when most orchard poisoning is done in Michigan, but often there are considerable periods, with or without snow on the ground, when temperatures are near freezing, skies are overcast, and relative humidity is high

beneath the grass cover of an orchard. Poisoned grain under this grass cover is quite well protected from wind and beating rains, but is often continuously moist. Records of temperature and amount and kind of precipitation made within a few hundred yards of the site of this experiment are given in Table 2.

*Table 2—Precipitation and maximum-minimum temperatures at East Lansing for the period of weathering of the poisoned grain (all data refer to the period from 8 a.m. of the stated date to 8 a.m. of the following day)**

Date, 1949	Precipitation		Temperature in degrees F.		Date, 1949	Precipitation		Temperature in degrees F.	
	Type	Amount in inches of water	Maximum	Minimum		Type	Amount in inches of water	Maximum	Minimum
Nov.					Dec.				
15....	snow.....	0.11	45	31	1...	snow.....	0.21	33	20
16....	.....	.....	35	31	2...	.....	.....	29	20
17....	.....	.....	33	30	3...	rain.....	0.22	38	17
18....	.....	.....	36	29	4...	.....	.....	39	29
19....	.....	.....	36	29	5...	.....	.....	35	20
20....	rain, snow.	0.06	.....	.....	6...	snow, sleet.	0.13	32	13
21....	.....	.....	37	21	7...	snow, sleet.	0.06	35	15
22....	.....	.....	25	12	8...	snow.....	0.01	24	17
23....	.....	.....	36	21	9...	.....	.....	25	13
24....	snow.....	0.83	36	20	10...	rain, sleet.	0.21	33	19
25....	.....	.....	29	20	11...	rain.....	0.11	61	32
26....	snow.....	0.11	28	−7	12...	.....	.....	60	22
27....	snow.....	0.02	.....	.....	13...	.....	.....	28	16
28....	rain.....	0.02	34	−4					
29....	rain.....	.....	37	28					
30....	.....	.....	43	29					

*Data furnished by courtesy of George A. Crabb, Jr., station supervisor, U. S. Department of Agriculture Soil Conservation Service, Michigan Hydrologic Research Station, in cooperation with the Michigan Agricultural Experiment Station, East Lansing.

The experimental method used to expose grain to weathering was designed to simulate natural conditions as closely as possible, yet to avoid rubbing the poisonous coating from the moist bait. Shallow plywood trays (inside dimensions about 36 x 5 x ¼ inches) were made to fit between the rows of a medium heavy stand of oats which had been sown as a cover crop. Each tray held about 200 grams of poisoned grain in a layer a single kernel deep. The poisoned grain used in this test was prepared in the same manner as for use in orchards, a special

effort being made to mix it thoroughly. As recommended by Eadie (5), to 100 pounds of coarse cracked corn were added 2 pounds of zinc phosphide mixed into 1 quart of vegetable oil with ½ ounce of methyl green dye.

Eight trays were exposed on the morning of November 16, 1949, and one of these trays was brought in every morning for a week. The remaining tray, the eighth, was left in the field until it had received an exposure of 27 days. The trays were put out during a snow flurry (Table 2) which deposited enough water to moisten the grain thoroughly. By November 20, the grain had started to dry, but rain and snow, along with lower temperatures, kept the trays covered with snow for the rest of the exposure period. During the entire time of exposure, the trays were undisturbed except for the attention of several mice as shown by occasional tracks and droppings and the passing of one pheasant as revealed by tracks down the length of one of the remaining trays on November 22.

As each tray was brought in, it was first allowed to stand at room temperature until the snow had melted and run off. Then, the tray was placed on a radiator of the heating system and dried for a few hours with heat never greater than that warm to the hand. Next, the tray was stored in a closed cabinet with calcium chloride until the grain was thoroughly dried. One-half of each sample was used in a bio-assay to determine the toxicity; the other half was used for the chemical determinations to be discussed later.

RESULTS OF BIO-ASSAY

The half of each sample designated for bio-assay was ground in a semi-micro Wiley mill to pass through a No. 20 screen. A quantity of unpoisoned cracked corn, ground in the same manner, was used to prepare from each sample three dilutions which were 0.45, 0.20, and 0.09, respectively, the strength of the original. With four levels of toxicity of each of the nine samples and the unpoisoned ground corn used as a control, there were 37 preparations to be tested against laboratory mice (Table 3).

All mice used were albino laboratory animals, offspring of the genetical colony of the Department of Zoology. Only non-pregnant female animals were used, to eliminate any variation associated with sex. Weights of animals used ranged between 18 and 36 grams and averaged 22.5 $\pm$ 3.3 grams (mean $\pm$ standard deviation). It was convenient to handle only about 22 animals at one time. Typically 2 of

Table 3—Number of laboratory mice dying (numerator) out of the total number tested (denominator) for each dilution of each sample of zinc-phosphide-poisoned cracked corn bait, and for the unpoisoned corn control.

Sample No.	Days weathered	Degree of dilution of the original			
		1.00 (original)	0.45	0.20	0.09
1	0	8/8	9/11	11/13	2/13
2	1	4/5	4/5	3/5	2/5
3	2	5/5	4/5	3/5	2/5
4	3	5/5	5/5	3/5	1/5
5	4	5/5	3/5	4/5	0/5
6	5	4/4	4/4	2/5	1/5
7	6	4/5	5/5	3/5	0/5
8	7	8/8	8/8	3/14	1/10
9	27	5/9	3/13	2/10	0/8
Control		0/28			

these 22 were control animals and the rest were allocated widely among the mixtures to be tested. The tests were accomplished in 15 such series between March 2 and August 22, 1950.

Animals were handled according to the following routine. In the late afternoon, the experimental animals to be used the following day were weighed and placed separately in cages with water but with no food. In the forenoon of the next day, each animal was given the same dose relative to its weight (0.02 times its own weight) of some one of the mixtures or the control, in a shallow metal dish. Doses were weighed to 0.01 gram on a torsion balance. After an animal had consumed its dose of grain, it was transferred to a cage with food, where it was kept with the other animals for several days or until it died. Any living animal which did not completely consume its dose before night of the day the poison was given was disregarded, although any animal dying before this time limit was counted whether or not it had finished the grain given it. This distinction was made because these laboratory mice did not always eat the mixtures readily, and the undiluted, less weathered, samples seemed especially repellent to certain animals. In all, 290 animals were used, but records of 23 of these were discarded for the reason outlined above. None of the 28 control animals died.

After the testing was well begun, it was apparent that the toxicity of the different samples varied, and that the longest-weathered sample

still retained appreciable toxicity. It was decided that the most economical use of available animals would result from more precise determination of three samples—the unweathered (sample 1), that which had weathered for 7 days (sample 8), and that which had weathered for 27 days (sample 9). Accordingly, larger numbers of experimental animals were used in testing those samples than were used with samples 2 through 7 (Tables 3, 4).

The median lethal dose for each sample was estimated according to methods outlined by Finney (7). Statistical tests showed the presence of no significant heterogeneity in the data. The slopes of the dosage-response curves for the different samples did not differ significantly and, therefore, a common slope was used, based upon all of the data, in computing the median lethal dose and its standard error for each sample. These values are shown in Table 4.

Table 4—Change in toxicity with weathering of cracked corn bait carrying 2-percent zinc phosphide, as shown by changes in the median lethal dose for laboratory mice

Sample No.	Days weathered	Number of mice	Median lethal dose in grams per kilogram	Log median lethal dose and its standard error
1	0	45	2.8	0.455 ± 0.092
2	1	20	3.8	0.574 ± 0.122
3	2	20	3.1	0.486 ± 0.127
4	3	20	2.8	0.451 ± 0.145
5	4	20	4.4	0.639 ± 0.139
6	5	18	3.9	0.590 ± 0.128
7	6	20	4.4	0.643 ± 0.127
8	7	40	5.1	0.705 ± 0.093
9	27	40	14.6	1.164 ± 0.097

It is clear that the toxicity of this poisoned grain did decrease with weathering, but that after 27 days, the bait still retained about one-fifth of its original potency. The values for median lethal dose are variable, but the entire set of data shows the trend of decreasing toxicity with further weathering (Fig. 1). Comparison of the relative toxicities of samples 1, 8 and 9 shows that sample 8 is less toxic than sample 1, with the statistical significance of the result at slightly over the 5-percent level (t equals 1.92), while sample 9 is less toxic than either sample 1 or sample 8, with each of these differences being significant at less than the 1-percent level (Table 6). Computed as a uniform geometric rate of deterioration, the trend of the data is equiv-

alent to a loss in toxicity of 6 percent per day of weathering (Fig. 1), and an analysis of variance shows this trend to be highly significant in a statistical sense (Table 7).

RESULTS OF CHEMICAL ANALYSIS

Chemical analyses of samples 1, 8 and 9 were carried out in the laboratory of the Department of Agricultural Chemistry, using the half of each sample not used for the bio-assay. The replicated quantitative determinations of phosphide phosphorus and of zinc are shown in Table 5, expressed as percentage content of zinc phosphide, computed separately on the basis of each determination of zinc and of phosphide phosphorus.

Analysis of the content both of phosphide phosphorus and of zinc allows determination of whether the observed loss of toxicity over the

Table 5—Phosphide phosphorus and zinc content of 3 samples of zinc-phosphide-poisoned cracked corn bait, unweathered and after weathering for 7 and for 27 days

Sample No.	Days weathered	Zinc phosphide equivalent, in percent*			
		According to phosphide phosphorus determined†		According to zinc determined‡	
		Values	Mean	Values	Mean
1	0	2.14		2.24	
		2.04		2.06§	
			2.09	2.09§	2.13
8	7	1.41		1.58	
		1.32		1.15	
			1.37	1.41§	1.38
9	27	1.14		0.96	
		1.05		1.33	
			1.10	0.95§	1.08

*Analyses made by the Agricultural Chemistry Department of Michigan State College.

†Phosphide phosphorus determined according to the method of Elmore and Roth (6).

‡After treating the corn with NH_2SO_4 and ashing in a muffle furnace at 500-550 C., the zinc was determined gravimetrically according to the method given in "Methods of Analysis, A.O.A.C.", sixth edition, p. 57 (1).

§These determinations of zinc were made upon ground corn like that used in bio-assay, all other determinations were made upon cracked corn bait. The poor agreement between duplicate values on cracked corn may be due to the difficulty of getting a uniform 1-gram sample.

period of weathering was attributable, 1, to physical erosion of the poisonous coating of the bait as suggested by Elmore and Roth (6), 2, to chemical breakdown of zinc phosphide with liberation of the gas phosphine (PH_3), or 3, to some other change in the poisoned bait.

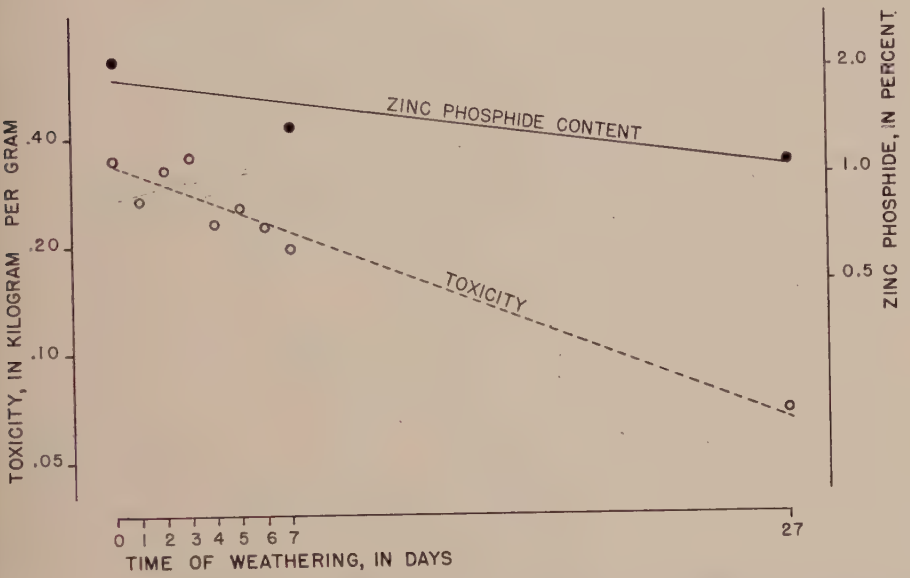

Fig. 1. Toxicity and content of zinc phosphide, plotted separately on logarithmic scales against the time of weathering in days. Values for toxicity are reciprocals of the corresponding median lethal doses in Table 4; values for zinc-phosphide content are from Table 5. The straight lines shown have been fitted to the respective sets of data by the method of least squares, using the relationship $y = a\ b^{x}$, where, for the toxicity data, y is the toxicity of bait after weathering for x days, a is the original toxicity before any weathering, and b is the proportion of the toxicity present at the beginning of a day which survives that day's weathering. From the computed value of b the daily proportional loss of toxicity may be estimated (1-b) as 5.77 percent per day of weathering. In the same manner, the daily loss of zinc-phosphide content may be estimated as 2.07 percent per day.

The phosphide-phosphorus content of the bait decreased with weathering, but the zinc content decreased at a closely parallel rate (Table 5). Since the bait lost both constituents of zinc phosphide at the same rate, the conclusion is tenable that the loss was due to a physical erosion of the zinc-phosphide coating. Had there been any appreciable evolution of phosphine gas, the content of zinc would have been expected to decrease less rapidly than the content of phosphide phosphorus.

The rate of loss of zinc phosphide by erosion may not have been uniform; the three samples analyzed show a higher average daily loss between sample 1 (unweathered) and sample 8 (weathered 7 days) than between sample 8 and sample 9 (weathered 27 days). It may be significant that snow covered the weathering grain for 3 or less of the first 7 days, but for all of the next 20 days. This snow probably shielded the grain from some of the erosive effects of wind, dust, and rain. The relative content by chemical analysis is shown in Table 6, for paired comparisons among the three samples.

Table 6—Relative toxicity by bio-assay and relative content of phosphide phosphorus by chemical analysis, for samples numbered 1, 8, and 9, which were weathered for 0, 7, and 27 days, respectively

Comparing samples numbered	According to bio-assay		According to chemical analysis	
	Relative toxicity	Log relative toxicity and its standard error	Relative content	Log relative content and its standard error
1 and 8	1.78	0.2508 ± .1305	1.53	0.1851 ± .0205**
1 and 9	5.10	0.7080 ± .1370**	1.91	0.2810 ± .0205**
8 and 9	2.88	0.4590 ± .1350**	1.25	0.0959 ± .0205*

*Difference from zero significant at the 5-percent level.
**Difference from zero significant at the 1-percent level.

The loss of zinc phosphide by weathering accounts partly, but not entirely, for the loss of toxicity demonstrated in the bio-assay of the weathered bait. The loss of phosphide phosphorus, expressed as a uniform rate of deterioration, amounted to about 2 percent per day, while the loss of toxicity was about 6 percent per day (Fig. 1). Whether this observed difference between rates of loss might originate solely from chance variation in the values observed may be tested by an analysis of variance. Logarithms of the observed values were used in computation for two reasons, first, because the treatment of toxicity data by probit analysis requires use of logarithms of dosage (7), and second, because when using logarithms the variability of the data and the trends with time, or rates of deterioration, may be compared directly for two sets of data even when the original measurements were made in two different kinds of units (toxicity in kilograms per gram and chemical content in percent).

The analysis of variance of the unweighted data, consisting of nine determinations by bio-assay and three by chemical analysis, shows that the fitting of a regression on time independently to each set of data reduces the variability by a highly significant amount, compared with use of a regression line with an average slope based upon both sets of data (Table 7). Therefore, it is very unlikely that the two observed rates of deterioration are merely estimates of the same rate of change. The statistical examination of the data thus con-

Table 7—Analysis of variance of logarithms of data from chemical analyses and bio-assay of zinc-phosphide-poisoned bait, for testing whether the observed difference between rates of deterioration with weathering, as shown in Fig. 1, might have arisen by chance

(Data from chemical analyses)

Source of variation	Degrees of freedom	Sum of squares	Mean square
Total	2	0.0401	
Regression on time	1	0.0325	0.0325
Deviation from regression	1	0.0076	0.0076

(Data from bio-assay)

Source of variation	Degrees of freedom	Sum of squares	Mean square
Total	8	0.3790	
Regression on time	1	0.3552	0.3552**
Deviations from regression	7	0.0238	0.0034

(Combined data)

Source of variation	Degrees of freedom	Sum of squares	Mean square
Total (from tables above)	10	0.4191	
Average regression on time	1	0.3245	0.3245**
Deviations from average regression	9	0.0946	0.0105
Deviations from individual regressions (from tables above)	8	0.0314	0.0039
Improvement through using individual regressions (or difference between slopes of individual regressions)	1	0.0632	0.0632**

**Significant at the 1-percent level.

firms the observation that the loss of toxicity was not entirely attributable to the loss of zinc phosphide by weathering.

The nature of that part of loss of toxicity not explained by loss of zinc phosphide is not known. The comparison between toxicity and chemical content shows that the zinc phosphide remaining after weathering was not as toxic per unit of weight as that before weathering, and suggests some difference in physical make-up. Either a change in physical structure as the chemical weathered, or simply a more rapid erosion of the more toxic elements (the more finely divided particles?), seems possible.

SUMMARY

Tests with 16 pheasants showed that zinc phosphide is highly toxic to these birds, with a median lethal dose being 9 milligrams per kilogram. Tests of cracked corn bait carrying 2 percent of zinc phosphide showed that after weathering for 27 days, the bait lost both zinc phosphide as determined by chemical analysis and toxicity as determined by bio-assay using laboratory mice. Loss of phosphide phosphorus was parallel to the loss in zinc, suggesting that chemical breakdown of zinc phosphide was unimportant and that the loss was by physical erosion of the zinc-phosphide coating of the bait. Since the rate of loss of toxicity exceeded the rate of loss of zinc phosphide, the loss of toxicity observed in weathering bait may be partly but not entirely explained as loss of zinc phosphide.

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culture, Soil Conservation Service, Michigan Hydrologic Research Station in cooperation with Michigan Agricultural Experiment Station, East Lansing. An analytical balance was made available for use at Kalamazoo College by Dr. A. B. Stowe of the Chemistry Department of that institution.

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GROWTH AND YIELDS FROM A FIFTY-YEAR-OLD WHITE PINE PLANTATION

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WHITE pine has been planted extensively on southern Michigan farms on eroded soils and as windbreaks. A detailed study of an older white pine plantation shows the returns that can be expected from these plantings.

The Beal Pinetum is the oldest plantation of white pine (*Pinus strobus* L.) in Michigan. It occupies a three-acre area just east of the Michigan State College campus at East Lansing. It was established in 1896 by Dr. W. J. Beal, the first professor of Botany and Forestry at Michigan State. The immediate purpose was to cover up an unsightly, abandoned gravel pit, but he hoped to show also that white pine could be grown as a forest crop, on land not suitable for the production of field crops. This area had been in corn before the gravel was dug, but the yields were submarginal.

The original planting was made, using a spacing of 8 by 12 feet, or 454 trees per acre. Five-year-old seedlings were used. The soil was prepared by plowing and disking, and the trees were planted in checked rows. They were cultivated the first year to control weeds. The soil for the most part is Berrien loamy sand. This is a deep sandy soil on level land, neither excessively dry nor wet. A small portion in the north part of the pinetum is Griffin sandy loam, which is an alluvial soil, characterized by a dark-brown to blackish sandy loam and is poorly drained. The plantation has a north and east exposure and is fairly level to perhaps a 5-percent slope along the bank of the Red Cedar River.

The growth of these trees indicates the feasibility of planting white pine on similar soils on southern Michigan farms. A twofold purpose can be served in this way. Acres that would otherwise be idle can be made to bear part of the expenses of the farming enterprise as a whole. An erstwhile eye-sore can be converted to a beauty spot, thus improving the general appearance of the farm. The pinetum indicates how white pine, planted on similar soils, will appear after 50 years of growth.

ARTICLE 33-54

HISTORY OF THE STAND

The growth of the pinetum has been measured periodically and from time to time articles have appeared, principally in the *Quarterly Bulletin*, on special phases of its management. Chittenden (3) published the measurements which were taken in 1916 and again in 1921. These are given in Table 1. He found that, even with the wide spacing with which the pinetum was established, after 25 years the crowns of the trees had closed so that the cover was fairly complete. No thinnings had as yet been necessary, but the lower branches had been pruned to a height of 15 feet.

Table 1—Number of trees, diameters, heights, and volumes

Date	Age	Trees per acre	Diameter of average tree	Height of average tree	Volume per acre	
					Long cords	Cu. ft.
1916.....	20	399	7.2 in.	34.4 ft.	17.7	1,596
1921.....	25	387	8.1	45.3	30.5	2,912
1925.....	29	381	8.7	54.0	42.8	4,560

Chittenden (4) reported on the results of the first thinning made in the pinetum in December 1925. The condition of the stand before the thinning is given in Table 1. The gradual decrease in the number of stems per acre is due to the crowding of the trees with increasing size and the consequent suppression and death of certain trees. The crowns did not have room to develop properly and the rate of growth in diameter ultimately decreased. This was determined by making ring counts of the stumps of 30 trees. Between the fifth and the fifteenth years after planting, the diameter growth of the average tree was about 6 inches, while between the twentieth and the thirtieth years it was only about 1 inch. Hence a thinning was desirable so as to increase the rate of growth.

About one-fifth of the trees by volume (845 cubic feet) and about one-third of the trees in number were removed in the thinning. Practically all the trees cut were in a sound condition and were free from disease and mechanical injury.

Bowman (1) made a study of the pinetum from the viewpoint of lumber production. He found that, as managed, the stand earned 4 percent compound interest on the amount of money expended from the time of its establishment to 1933.

The expenditures per acre are listed as follows:

Value of the land in 1896	$15.00
Cost of planting stock in 1896 (454 trees @ $32 per thousand)	14.50
Cost of planting	5.00
Cost of pruning all the trees in 1920	13.00
Net cost of thinning in 1925	0.25
Total expenditures	$47.75

The stand in 1932 contained 15,875 board feet per acre in 252 trees. Bowman allowed $10 per thousand board feet for stumpage. This was the average figure for standing white pine in 1929 to 1932. This brings the sale value of the standing timber in 1933 to $158.75 per acre. No charges for taxes were included because this stand is on state land.

Bowman (2) used the pinetum to show that a planted white pine stand is more profitable than natural hardwoods. He compared this stand with an adjoining hardwood stand on an equally good site for tree growth. This hardwood stand is managed for maple syrup production as well as timber growth. The volume growth in the 15-year period for the white pine was from 1,596 cubic feet per acre in 1916 to 3,941 cubic feet in 1931, as compared with the volume growth in the older hardwood stand from 2,900 cubic feet in 1916 to 3,792 cubic feet in 1931. The volume growth of the pines during this period was 5.5 percent per year as compared with 1.8 percent per year for the hardwood stand. Based on stumpage prices for that period, the comparative cash increases per year are shown in Table 2.

Adding $1.06 per acre per year, as an average profit from the production of maple syrup, to the earnings of the hardwood stand brings the total only to $3.45. Thus, it would be more profitable to grow white pine which yields an increase of $5.90 per acre per year.

Stoehr (6) found that the pinetum, in spite of its small size, included different productivity sites. The index of productivity was taken as the average height of the dominant trees at age 50. A site index map, Fig. 1, was prepared by establishing a grid layout of tenth-acre plots. Site indices ranged from the 60- to the 80-foot class. This

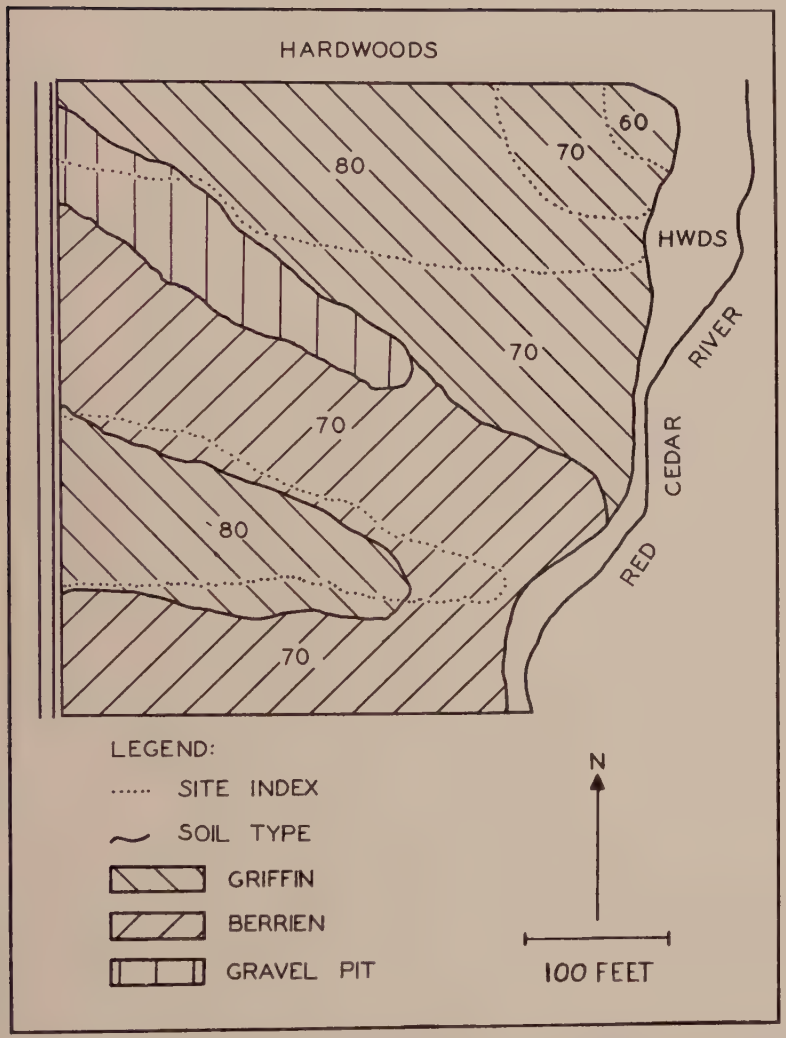

Fig. 1. Soil type and site index map of the pinetum. Site index is taken as total height at age 50 years.

Table 2—Increase per year in volume and value, hardwoods vs. white pine, 1916-31

Species	Increase per acre per year	Estimated stumpage value in 1931	Increase in cash value per acre per year
Sugar maple.....	70 bd. ft.	$17.50 per M ft.	$1.22
Beech.....	64	5.70	.37
American elm.....	50	6.60	.33
Basswood.....	20	6.60	.13
White ash.....	12	20.00	.24
Others.....	17	5.70	.10
Total.....	233		$2.39
White pine.....	590	$10.00	$5.90

apparently represents the effect of different soil types, together with the varying depths of the surface soil layer. The lowest site index was found where the area was inundated every year by the Red Cedar River, in spite of the deep layer of fertile surface soil. Evidently white pine does not grow rapidly on wet land or flood plains.

No major thinnings have been made since 1926, but periodically trees have been removed and utilized as they showed loss of vigor. Strong (7) reports that 12 trees that were blown down by high winds in 1940 were found to be infected by the root rot fungus (*Polyporus schweinitzii*, Fr.). These were removed and utilized as soon as their condition was detected. Also, two trees developed witch's brooms in their crowns which caused the overweighted tops to break off. These trees were also removed and utilized. In all, 76 trees were removed from the stand during the period 1932-46. Most of them were in the process of being crowded out by their fellows, but were otherwise healthy. All trees removed in this period were in a usable condition. As of 1946 there were 176 trees per acre. They averaged 12 inches in diameter, and the volume was 16,300 board feet per acre. The average height of the dominant trees was 75 feet. The effect of the major thinning in 1925 can be seen on the face of freshly cut stumps. Acceleration of growth in diameter was evident the following year and continued for the next five years, after which time the rate of diameter growth seems to have been the same as it was before the thinning. The 50-year condition of the stand is given in Table 3.

Table 3—Number of trees and volumes per acre by diameter classes at 50 years

Diameter class	Trees per acre	Volume per acre
7	4.4	.....
8	2.9	.....
9	8.9	.....
10	17.8	830 bd. ft.
11	27.0	1,820
12	36.2	3,270
13	35.3	3,840
14	23.0	3,040
15	13.0	2,090
16	4.4	800
17	2.1	450
18	.7	160
Total.....	175.7	16,300

A summary of the growth data for the pinetum from all information available is given in Table 4. These measurements are presented in graphic form in Figs. 2, 3, 4, and 5 to show their curvilinear relationships with age.

Table 4—Growth data for the pinetum, 1896-1946

Year	Age	Trees per acre	Diameter average tree	Height of dominants	Volume per acre		Volume per average tree
					Cu. ft.	Bd. ft.	
			in.	*feet*			*cu. ft.*
1896...	0	454	.....	.....	.....	.....	.....
1916...	20	399	7.2	34	1,596	.....	4.0
1921...	25	387	8.1	45	2,912	.....	7.5
1925...	29	381	8.7	54	4,560	.....	12.0
*1925...	29	253	9.1	54	3,715	.....	15.0
1932...	36	252	10.4	64	5,300	15,875	21.0
1946...	50	176	12.4	75	6,690	16,300	38.0

*After thinning.

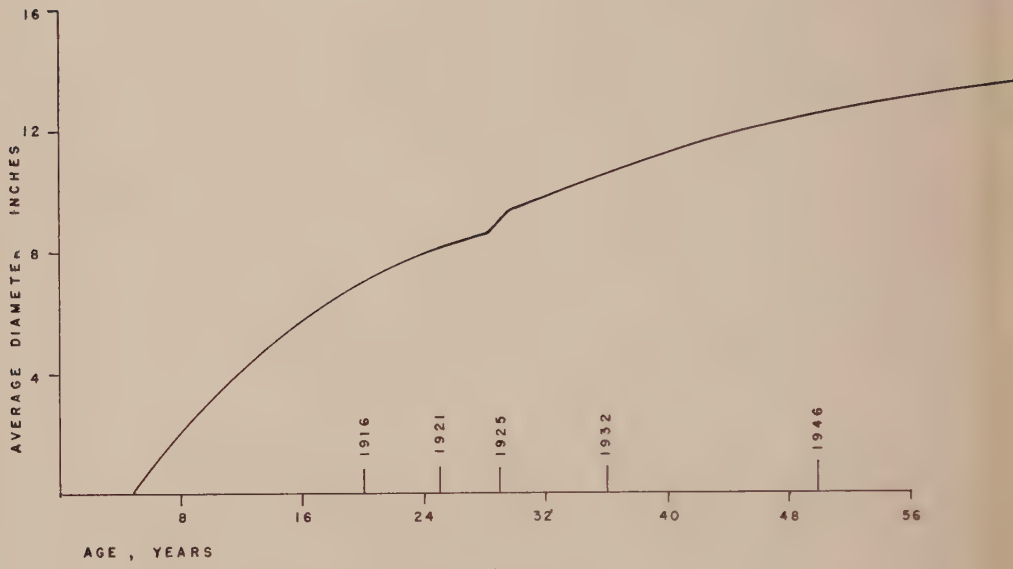

Fig. 2. Diameter growth, pinetum trees.

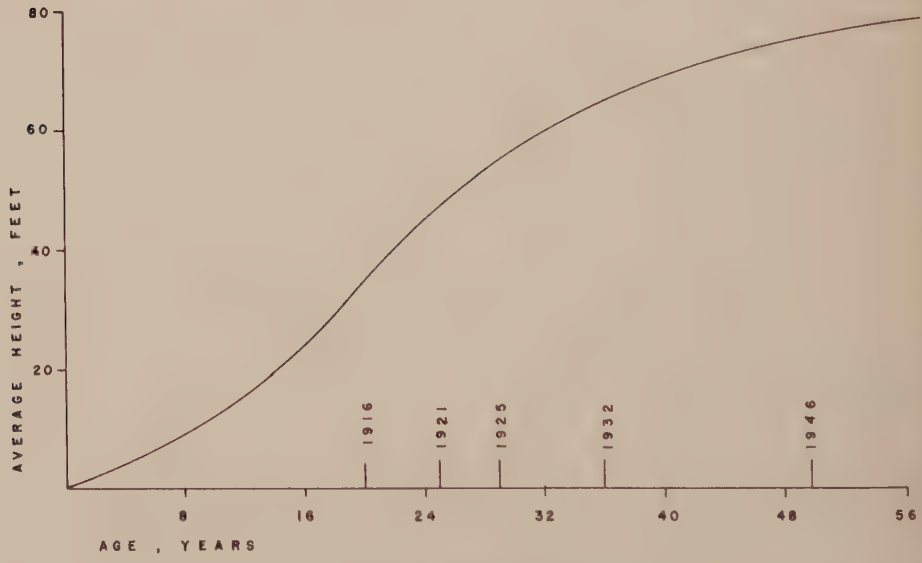

Fig. 3. Height growth, pinetum trees.

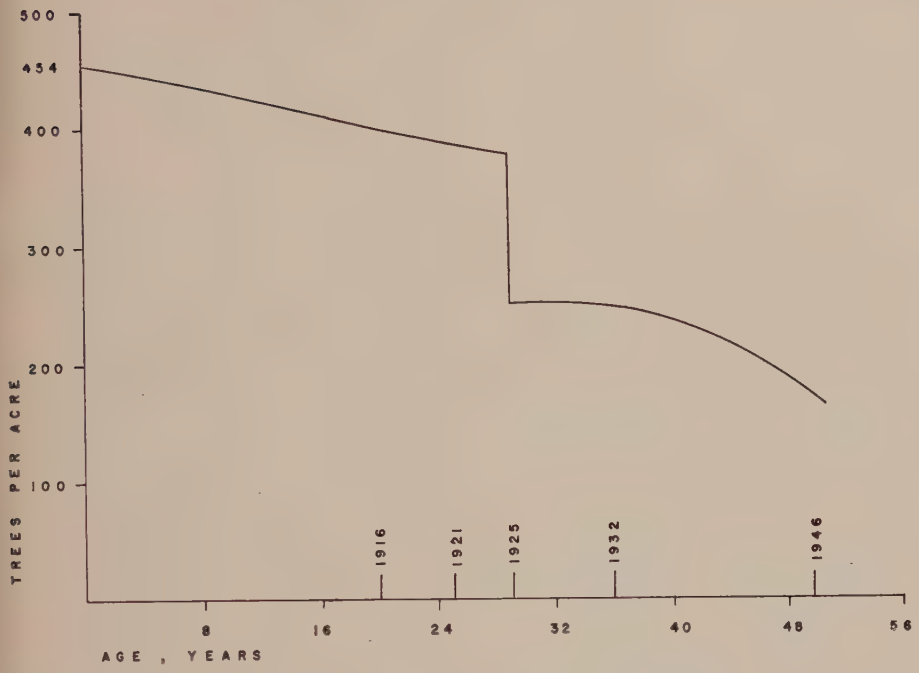

Fig. 4. Number of trees per acre, pinetum trees.

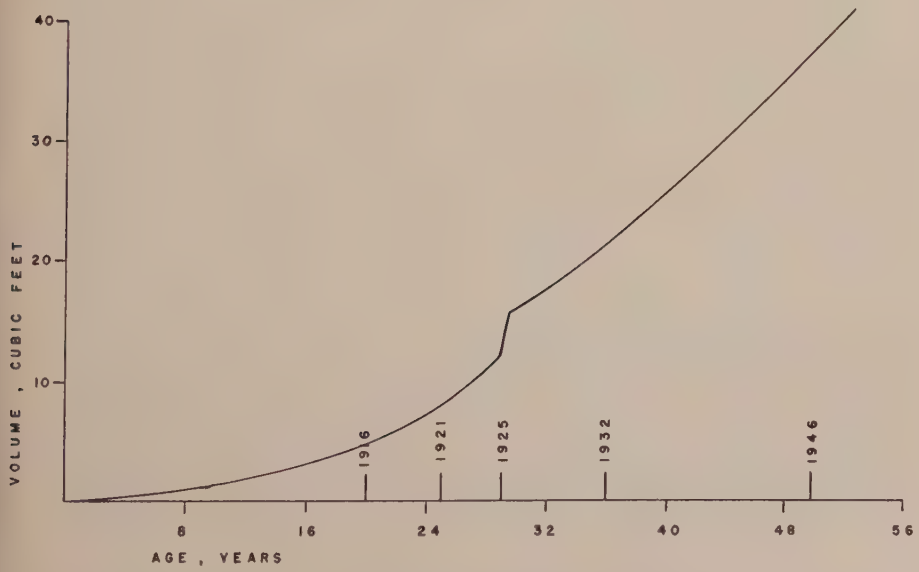

Fig. 5. Cubic foot volume of average tree.

FINANCIAL CONSIDERATIONS

Table 5 shows the expenditures and the value of the products derived from the pinetum on a per acre basis. The expenditures on the three-acre area have been less than the estimated value of the wood produced, the profit being about $17 per acre.

Table 5—Costs and returns from three acres of white pine in 50 years

Costs per acre:	
Cost of planting stock in 1896 (454 trees @ $32 per M., plus 4% interest for 50 years)	$103.25
Cost of planting in 1896 ($5 per acre plus 4% interest for 50 years)	35.54
Cost of pruning in 1920 ($13 per acre plus 4% interest for 30 years)	42.16
Net cost of thinning in 1925 ($0.25 plus 4% interest for 25 years)	.67
Total costs per acre	$181.62
Returns per acre:	
Stumpage value, 1946 (16,300 bd. ft. @ $10 per M)	$163.00
Trees cut in thinnings (1932 to 1946) (2,700 bd. ft. from 76 trees @ $10 per M. plus 4% interest for average period 7 years)	35.53
Total returns	$198.53
Net profit as of 1946	$ 16.91

The profit represented is without taxes because this land is owned by the state and is tax-free. This represents an annual earning of 34c per acre for the 50-year period, on land that might possibly be taxed 10c per acre, if considered as part of a farm. The cost of the land does not enter into the calculations inasmuch as the value of the bare land

was seen to be nil for agricultural use. Four percent compounded annually was used as a charge against borrowed money, comparable to a long term loan from a federal land bank. Stumpage price (for standing trees) may be considered as ridiculously low for these times, but ultra-conservatism was introduced by using $10 per M board feet

Fig. 6. The pinetum after 50 years of growth. Average size tree is 12 inches in diameter and 75 feet total height.

as an average for the past 25 years. Profits would be considerably higher if one took advantage of peak market prices.

PREDICTIONS AND RECOMMENDATIONS

In 1950, the stand averaged 13.2 inches in diameter, 78 feet in height and contained 16,500 board feet per acre. This amounts to a growth of 50 board feet per acre per year for the past 4 years, and a diameter growth of 0.2 inch per year. If mortality continues at the same rate as from 1932 to 1950—about five trees per acre per year for the next 15 years—there will be 100 trees per acre in 1961. They will average 15.4 inches in diameter, and will be spaced an average of 21 feet apart. The stand will then be considerably more park-like, and mortality is expected to drop to an average of two trees per acre per year. Thus by the time the stand is 100 years old, in 1996, there will still be 30 trees per acre. If the rate of diameter growth of 0.2 inch per year continues, the stand will average 22 inches in diameter, and the trees will be spaced on an average of 35 feet apart.

It is recommended that this stand be kept as a memorial, in as good a growing condition as possible as long as any of the original trees remain. It is also suggested that beginning in 1960, some of the openings in the stand be planted to esthetic groupings of white spruce or red pine, at intervals of five years. By 1996 the density of the original stand will be down to about 80 square feet of basal area per acre and the plantings established in 1960 and every five years thereafter, will begin to take over the area. The result will be a perpetuation of the forest on a many-aged basis. It is not recommended that white pine be planted following white pine because of its intolerant nature.

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JOURNAL ARTICLE ABSTRACTS

The Use of a Discriminant Function in Textile Research

Baten, W. D.; Ford, Merle, and Heitz, Ruth M.

Textile Research Journal 20:869-872. 1950 (Journal Article 716 from the Michigan Agricultural Experiment Station)

The article shows how a discriminant function may be employed for distinguishing significant differences between types of textile materials on which measurements of several characteristics are made. This statistical technique enables one to use all measurements combined into a composite for a test of significance instead of carrying out tests on each factor separately. A real difference may not be revealed when a test is based upon one or two factors, but may be manifested when based upon more than two. A discriminant function enables one to utilize all measurements of all factors and, in many instances, permits one to detect real differences between entities without extra sampling, which may be prohibitive. A discriminant function points out the ranks of importance of the various characteristics.

Towels made of linen, cotton and linen, cotton and rayon were tested for differences by measurements of the breaking strength of warp and filling, shrinkage of warp and filling and percentage of absorption. Analyses of variances of the discriminant functions revealed significant differences between each type of towel.

The Response of Thyroidectomized and Intact Dogs to Thyroidal Stimulation

Borgman, R. F., and Reineke, E. P.

Amer. Jour. Vet. Res. 11(39):149-156. 1950 (Journal Article 1065 from the Michigan Agricultural Experiment Station)

In order to determine suitable levels of administration for therapeutic use in dogs, experiments were conducted with "protamone", an iodinated protein having high thyroidal activity, and also with a desiccated thyroid preparation. The response to each of these preparations was determined by the amount required to return the metabolic rate of thyroidectomized dogs back to the normal level.

Doses of 1 mg. of protamone per kilogram of body weight per day and 4 to 8 mg. per kilogram per day of 50 percent stronger than U.S.P. desiccated thyroid were required to raise the metabolism of thyroidectomized dogs back to the normal range. Thus, the therapeutic range may be estimated as follows: 1 to 2 mg. per kilogram per day of protamone and 6 to 12 mg. per kilogram per day of desiccated thyroid U.S.P.

Adult dogs were able to tolerate doses up to 8 mg. of protamone per kilogram per day for a month without demonstrable hyperthyroid symptoms.

Protamone had four to eight times the potency of desiccated thyroid (50 percent stronger than U.S.P.) as assayed by calorigenic effects on thyroidectomized dogs. The most probable ratio between the two is 5:1.

Protamone and desiccated thyroid (50 percent stronger than U.S.P.) both caused a transient drop in the metabolic rate on the seventh to eighth day of dosage. Large doses of up to 28 mg. of protamone per kilogram per day did not cause a marked rise in the metabolic rate of normal dogs.

The protamone antagonized the action of the parathyroid gland, causing tetany in dogs thyroidectomized, with two the parathyroids removed, while under the influence of protamone. The incidence of tetany was proportional to the previous dosage of protamone.

Replacement therapy with protamone and desiccated thyroid alleviated the symptoms of thyroidectomy.

Thyroidectomy resulted in a 27.8-percent drop in the metabolic rate and a decline in pulse rate and body temperature. The body weight increased subsequent to thyroidectomy probably because of increased deposition of body fat.

Desiccated thyroid had a greater effect upon the pulse rate relative to its metabolic effect than did protamone.

The body weights of dogs increased when they received moderate daily amounts of protamone.

The Preservation of Vibrio Fetus by Lyophilization

STOCKTON, JACK J., AND NEWMAN, JOHN P.

Cornell Vet. 40(4):377-379. 1950 (Journal Article 1099 from the Michigan Agricultural Experiment Station)

Two strains of *Vibrio fetus* were dried by ice sublimation employing the cryochem process. Four-day old cultures were suspended in sterile skimmilk, frozen at −73 C. and dried at approximately 50 microns of pressure. Vibrios dried in this manner and stored at 4 C. were found to remain viable for at least 435 days.

Influence of Spray Materials on the Structure of Sour Cherry Leaves (Prunus cerasus L., Var. Montmorency)

JOHNSEN, E. M.; KENWORTHY, A. L., AND MITCHELL, A. E.

Amer. Soc. Hort. Sci. 55:195-198. 1950 (Journal Article 1106 from the Michigan Agricultural Experiment Station)

Total depth of the palisade layer was measured in sour cherry leaves (*Prunus cerasus L.*, Var. Montomorency.) The trees from which the leaves were picked had received various spray programs. These programs were found to effect significantly the palisade development. Leaves sprayed with basic copper sulfate had less development of palisade mesophyll than leaves sprayed with ferric dimethyldithiocarbamate. Leaves sprayed with ferric dimethyldithiocarbamate had less palisade development than leaves sprayed with liquid lime-sulfur. Spraying the leaves with parathion resulted in greater palisade development than spraying with benzene hexachloride or arsenate of lead. The use of basic copper sulfate in combination with benzene hexachloride resulted in the least palisade development. Spraying with liquid lime-sulfur in combination with parathion resulted in the greatest palisade development.

The Influence of Day Length and Temperature on the Growth and Flowering of Callistephus Chinensis Nees

LIN, LOK-CHIEN, AND WATSON, DONALD P.

Proc. Am. Soc. Hort. Sci. 55:441-446. 1950 (Journal Article 1114 from the Michigan Agricultural Experiment Station)

Asters were grown at a temperature of 50° and 60° F., and each group was subjected to long and short-light period. Floral initiation was found to occur 15 days earlier under "high temperature-long day" than "high temperature-short day" treatments, 30 days earlier at "low temperature long day" than "low temperature-short day" treatments. Floral initiation occurred under "low temperature-long day" conditions at about the same time it occurred under "high temperature-long day" conditions. Artificial light supplementing daylight for 5 hours at the high temperature resulted in budding 15 days earlier and reducing the flowering period by 8 days. At low temperature, with the use of supplementary light, budding occurred 25 days earlier and the flowering period was reduced by 5 days.

A Four Year Study of Listeriosis in Michigan

GRAY, M. L.; STAFSETH, H. J., AND THORP, FRANK, JR.

Jour. Am. Vet. Med. Assoc. 118(889):242-252. 1951 (Journal Article 1115 from the Michigan Agricultural Experiment Station)

This report presents 52 cases of listeriosis that have occurred in sheep and cattle of Michigan during a four year period. With the exception of a single case, a septicemia in an eight-day lamb, all displayed impairment of the central nervous system. Of several technics, one involving the use of a Waring blendor was found to be most satisfactory for the isolation of *Listeria monocytogenes* from infective material. Colonies of *Listeria* were shown to be readily distinguishable from other bacterial flora with the employment of a dissecting microscope and oblique light. Various aspects of the epizoology of the disease were discussed, but the mode of transmission could not be determined. It was shown that *Listeria* survived for from 6 to 26 weeks on sterile straw, hay, feed, etc., under barn environment.

Effects of Hypo- and Hyperthyroidism in Rats and Mice on Ovarian Response to Equine Gonadotrophin

JOHNSON, THOMAS N., AND MEITES, JOSEPH

Proc. Soc. Exp. Biol. and Med. 75(1):155-157. 1950 (Journal Article 1118 from the Michigan Agricultural Experiment Station)

The effects of experimentally induced hypo- and hyperthyroidism on the ovarian response to pregnant mares' serum were determined in immature rats and mice by administering thiouracil for 4 to 20 days and thyroxine or thyroprotein for 10 days. A constant dose of PMS was injected into each animal during the last 4 days of each experiment and the increase in ovarian weight was measured. It was found in rats that all doses of thyroprotein or thyroxine significantly decreased the action of the gonadotrophin on the ovaries, while in mice thyroprotein significantly increased the ovarian response to PMS. When thiouracil was fed to rats for 4-, 7-, 10- and 15-day periods, there were significant increases in ovarian

response to PMS, but when fed for 20 days thiouracil reduced the ovarian response to PMS. These data on young female rats and mice corroborate the results previously obtained in young male rats and mice. It is suggested that insofar as the ovarian response to PMS is concerned, young rats of both sexes secrete more and young mice less than an optimal amount of thyroid hormone.

Protection of Strawberry Plants with Activiated Carbon in Pre-Planting Applications with 2,4-D

CARLSON, R. F.; MOULTON, J. E., AND HAMNER, C. L.

Proc. Am. Soc. Hort. Sci. 55:268-270. 1950 (Journal Article 1124 from the Michigan Agricultural Experiment Station)

The use of activated carbon to protect newly set strawberry plants from 2,4-D showed promise in field tests in 1949. Before setting the plants, the herbicide 2,4-D was applied to the soil at the rates of 4 and 6 pounds per acre. Before setting the plants in the treated soil, the roots were first dipped in a dust of activated carbon. It has previously been demonstrated that activated carbon will adsorb and inactivate 2,4-D. The soil was disturbed as little as possible when setting the plants in order not to destroy the herbicidal action by bringing to the surface untreated soil.

The treatments and plantings were made before and after a one-inch rain, thus also giving information on effect of rainfall. The activated carbon gave some protection to the strawberry plants in the treatments made before the rain, especially so at the high rate of 6 pounds of 2,4-D per acre. The rain that followed the treatment evidently leached and diluted the 2,4-D enough so that injury was slight even where carbon was not used. In the treatments made after the rain, the activated carbon protected the plants both at the four and six pound rates. Only a few plants survived where carbon was withheld. The 2,4-D remained in the root zone for the dry period following the last treatment. Only a few grasses and some resistant species of broad-leaved weeds appeared during the season.

Effect of Boning on Cooking Losses and Palatability of Beef

PAUL, PAULINE; MORR, MARY L.; BRATZLER, LYMAN, AND OHLSON, MARGARET A.

Food Technology 4(9):348-349. 1950 (Journal Article 1125 from the Michigan Agricultural Experiment Station)

Beef carcasses completely boned and packaged require significantly less frozen storage space and can provide smaller sized packages than comparable carcasses packaged with little or no boning.

The cooking time, cooking losses, palatability, and nitrogen and phosphorus contents were very similar for bone-in and boneless beef cuts, the differences being too small to be significant. The major differences found were between different cuts cooked by the same method. The chuck roasts had the highest cooking losses of any of the braised cuts. The club steaks were the most tender and the sirloin steaks the least tender of the three kinds of steaks. The rump roasts received lower scores for flavor of fat, while the short ribs were given high scores for juiciness among the braised cuts. The lower juciness scores for rump and chuck may be a reflection of the longer cooking time for these cuts.

Pathology of the Chick Embryo Infected with Infectious Bronchitis Virus

LOOMIS, L. N.; CUNNINGHAM, C. H.; GRAY, M. L., AND THORP, F., JR.

Am. Jour. Vet. Res. 11 (40):245-251. 1950 (Journal Article 1126 from the Michigan Agricultural Experiment Station)

Infectious bronchitis virus recovered from chickens and injected into embryonating chicken eggs via the allantoic sac produced gross and microscopic pathologic alterations of the embryo, extra-embryonic membranes and fluids, the internal organs that are considered to be pathognomonic of infection with the virus. These alterations were produced on the first and seven subsequent passages of the virus. The principal alterations were "curling" and dwarfing of the embryo, adherence of the chorioallantoic membrane to the shell, thickening of the amnionic membrane and a subnormal volume of amnionic fluid, hepatitis, nephritis, pneumonia and congestion of the spleen. Inclusion bodies were not observed.

Absorption, Translocation and Persistence of 2,4-Dichlorophenoxyacetic Acid in Some Plants

DHILLON, A. S., AND LUCAS, E. H.

Bot. Gaz. 112(2):198-207. 1950 (Journal Article 1131 from the Michigan Agricultural Experiment Station)

The recovery of the active principle from plants, which were modified by the application of sodium 2,4-dichlorophenoxyacetate, is described. The authors do not conclude that the active principle is identical with the growth regulator applied because no identifiable crystalline material was recovered. However, the biological test and the qualitative color reaction with chromotropic acid furnished sufficient proof for the assumption that 2,4-D was absorbed and translocated in molecular form.

The authors show the persistence of 2,4-D which had traveled from the point of application through the plant tissue in several directions and by way of xylem as well as phloem. Extracts made from plants, which had been treated with an aqueous solution of the sodium salt of the growth regulator and allowed to grow for 26 days after the treatment, caused similar responses in bean plants as direct applications of 2,4-D.

Further Investigations of the Effects of "Hormone" Sprays on the Fruiting Response of Outdoor Tomatoes

WITTWER, S. H., AND SCHMIDT, W. A.

Proc. Amer. Soc. Hort. Sci. 55:335-342. 1950 (Journal Article 1136 from the Michigan Agricultural Experiment Station)

Previously reported studies have established that hormone sprays improve early and in some instances, total yields of field tomatoes if the sprays are applied to the first flower clusters when prevailing night temperatures are below 59° F. An additional two years' study has demonstrated that early yields, but not necessarily total yields, of tomatoes can be significantly increased by two or three spray applications of 30 ppm. p-chlorophenoxyacetic acid to the early flower clusters. The pattern of fruit harvest is also altered in that a part of the yield is

shifted forward in the season, and the usual peaks of concentrated production are leveled out.

Whole plant hormone sprays have also given slight increases in early yield. However, examination of the production pattern for a given crop has revealed that the usual temporary early gain is followed by drastic yield reductions, and the peaks of production late in the season are preceded by very light pickings. The results of the present paper and those of other germane investigations suggest that the threshold concentration of a hormone that is optimum for growth stimulation varies with the ontogeny of the reproductive organs. On this premise, the use of growth substances applied as whole plant fruit-setting sprays to tomato plants of indeterminate growth, whereon all phases of reproductive development are simultaneously present, will prove of little practical benefit and may decrease rather than increase yields.

Riboflavin Deficiency in the Lamb

LUECKE, R. W.; CULIK, R.; THORP, F., JR.; BLAKESLEE, L. H., AND NELSON, R. H.

Jour. An. Sci. 9(3):420-425. 1950 (Journal Article 1146 from the Michigan Agricultural Experiment Station)

Three-day-old lambs were successfully raised on a liquid purified diet. The lamb, in the pre-ruminant stage, has a definite requirement for riboflavin when fed the riboflavin-free milk. Symptoms of riboflavin deficiency were lowered appetite, poor growth and finally pneumonia. Administration of riboflavin to the deficient lambs alleviated all of the deficiency symptoms.

The Nutritive Value of Alfalfa Hay. IV. Beet Pulp, Corn Gluten Meal and Soybean Oil Meal as Supplements to an All-Alfalfa Hay Ration for Milk Production

HUFFMAN, C. F., AND DUNCAN, C. W.

Jour. Dairy Sci., 33(10):710-720. 1950 (Journal Article 1150 from the Michigan Agricultural Experiment Station)

Sixteen cows which had been depleted of the grain factor(s) were used in 21 trials to study the effect on milk production by replacing part of the total digestible nutrients in an all-hay ration with either beet pulp, sugar beets, corn gluten meal or soybean oil meal. In nine of the ten trials a significant increase in 4-percent fat-corrected milk was obtained when various levels of beet pulp or sugar beets replaced an equal amount of total digestible nutrients in the hay. In nine of eleven trials a significant increase in fat-corrected milk was obtained when various amounts of corn gluten meal or soybean oil meal replaced an equal amount of total digestible nutrients in the hay.

The tendency for the percent of butterfat in the milk to increase when beet pulp or sugar beets replaced part of the hay was pointed out. In view of the low-fat content of beet pulp, sugar beets, and most of the corn gluten meals and soybean oil meals used in these trials, it is apparent that the first deficiency of an all-hay ration for milk production is not fat *per se*.

The results indicate that the so-called grain factor(s) or the unidentified milk-stimulating factor(s) is stored in beet pulp, sugar beets, corn gluten meal and soybean oil meal.

The Dandelion and Its Influence on Bee Behavior During the Fruit Blossoming Period

KREMER, J. C.

Proc. Amer. Soc. Hort. Sci. 55:140-146. 1950 (Journal Article 1151 from the Michigan Agriculutral Experiment Station)

The prevailing temperatures during the fruit blossoming period have a decided influence on bee behavior. Dandelions considered as a competitor of fruit bloom for bee visitation, prefer a cool temperature of 55° to 70° F. for pollen dehiscence and nector secretions. Fruit bloom from 65° to 80° F. At 65° to 70° F. competition may exist for some time on days with slowly rising temperatures. This period of competition is negligible, on days with rapidly rising temperatures. The higher temperatures cause closure of the dandelion bloom and bee activity is devoted entirely to that of fruit bloom.

The Effectiveness of Some Antifoaming Agents in the Condensing of Skimmed Milk and Whey

BRUNNER, J. R.

Jour. Dairy Sci. 33:741-746. 1950 (Journal Article 1152 from the Michigan Agricultural Experiment Station)

A laboratory model vacuum pan, designed to give operational performance comparable with production size units, was employed to study the effectiveness of various materials as antifoaming agents in the condensing of skimmilk and whey. Milk, cream and butter as well as selected surface-active, chemical compounds were added to skimmilk and whey during the condensing operation. Cream and/or butter were moderately effective as foam depressants. Slightly rancid milk and/or cream were extremely effective foam inhibitors. Of the chemical antifoaming agents studied, the silicone compound, mono and diglyceryl esters of stearic acid and sorbitan monolaurate constitute those used most effectively to eliminate the excessive foaming tendency of skimmilk and whey. These materials are water-insoluble, surface-active substances.

A Duodenal Fistula in the Bovine Animal for Experimental Investigation

YOUNG, F. W.

Jour. Am. Vet. Med. Assoc. 118(887):98-100. 1951 (Journal Article 1154 from the Michigan Agricultural Experiment Station)

The detailed operative procedure is described for making a duodenal fistula in the bovine for experimental investigations in digestion.

The Control of Storage Sprouting in Onions by Preharvest Foliage Sprays of Maleic Hydrazide

WITTWER, S. H., AND SHARMA, R. C.

Science 112(2916):597-598. 1950 (Journal Article 1157 from the Michigan Agricultural Experiment Station)

The effects of preharvest foliage sprays of several growth regulators on sprout inhibition and storage quality of yellow Sweet Spanish onions were determined.

Sprouting and root growth in storage were completely inhibited by the application of a water spray of 2500 ppm. of maleic hydrazide (1, 2 dihydropyridazine-3,6-dione) to the foliage 2 weeks before harvesting the bulbs. Partial sprout inhibition was achieved by 500 ppm. of maleic hydrazide. Associated with the chemical inhibition of sprouting was an appreciable decrease in storage breakdown. A similar use of other chemicals such as the sodium salt of alpha-naphthaleneacetic acid, 2,4,5-trichlorophenoxyacetic acid, sodium salt of beta-naphthoxyacetic acid and benzothiazol-2-oxyacetic acid gave no significant control of sprouting or stimulated it, and resulted in bulb abnormalities which shortened rather than prolonged storage life.

The Effect of Preharvest Foliage Sprays of Certain Growth Regulators on Sprout Inhibition and Storage Quality of Carrots and Onions

WITTWER, S. H.; SHARMA, R. C.; WELLER, L. E., AND SELL, H. M.

Plant Physiology 25(4):539-549. 1950 (Journal Article 1158 from the Michigan Agricultural Experiment Station)

The effects of preharvest foliage sprays of several growth regulators on sprout inhibition and storage quality of Danvers, Nantes, and Chantenay carrots and Sweet Spanish onions were determined. Sprouting and root growth of onions in storage were completely inhibited by the application of a water spray of 2500 ppm. of maleic hydrazide (1, 2 dihydropyridazine-3, 6-dione) to the foliage 2 weeks before harvesting the bulbs. Partial sprout inhibition was achieved by 500 ppm. of maleic hydrazide. Other chemicals either gave no significant control of sprouting or stimulated it. Rotting was in some instances more prevalent than in controls. Sprout growth of stored carrots was completely inhibited by foliar sprays of 2500 ppm. of both maleic hydrazide and benzo-thiazol-2-oxyacetic acid applied 4 days before harvest. The maleic hydrazide did not significantly alter the amount of dry matter, carotene, carbohydrates or Kjeldahl nitrogen in the stored carrots. Sprouting in carrots was also significantly reduced by foliar sprays of the sodium salt of alpha-naphthaleneacetic acid, 1000 and 5000 ppm., and by 500 ppm. of either maleic hydrazide or benzothiazol-2-oxyacetic acid. Accompanying the use of chemicals other than maleic hydrazide and, to a lesser extent, benzothiazol-2-oxyacetic acid on carrots were frequent callus formations, proliferations and other abnormalities which tended to shorten rather than prolong the storage life of both carrots and onions.

The Parenteral Use of Penicillin and Streptomycin in Complications of Distemper

EADS, F. E.

North Amer. Vet. 32(1):32-36. 1951 (Journal Article 1161 from the Michigan Agricultural Experiment Station)

Amorphous penicillin was an effective agent in controlling the secondary invaders of canine distemper when administered at the rate of 1,000 to 1,500 units per pound of body weight four to six times per day. Streptomycin showed little, if any, value in the treatment of canine distemper.

Amorphous penicillin can be safely administered six times daily for 26 days with no untoward effects other than irritation at time of injection.

Streptomycin was an effective antibiotic in the treatment of 30 of 34 cases of infectious feline enteritis when administered at the rate of 0.2 to 0.25 gm. in a single daily injection.

The Choline Content of Fresh and Stored Shell Eggs

Evans, R. J., and Davidson, J. A.

Poultry Science 30(1):29-33. 1951 (Journal Article 1162 from the Michigan Agricultural Experiment Station)

Hens kept in laying cages were fed a diet of constant composition. Fifteen consecutive eggs from each of ten hens were used in the study. Three-egg samples from each hen were analyzed fresh and, also, after 3, 7, and 12 months of storage by the Reineckate method. Fresh egg yolks contained 14.9 mg. of choline per gm. of yolk or 251 mg. per egg yolk. Fresh egg albumen contained only 0.4 mg. per egg, so that the choline content of the fresh eggs was essentially the same as that of the yolks. No losses of choline from the egg occurred during twelve months of cold storage. The choline content of the albumen of 12-month-old eggs was on an average eight times as large as that of fresh eggs, indicating a transfer of choline from the yolk to the albumen in very small quantities. A transfer of water and, perhaps, some albumen solids to the yolk occurred which explains an apparent decrease in choline concentration in the yolk during storage.

Borders and Openings of Beech-Maple Woodlands in Southern Michigan

Gysel, L. W.

Jour. Forestry 49(1):13-19. 1951 (Journal Article 1166 from the Michigan Agricultural Experiment Station)

An ecological study was made in six different woodlands on similar upland sites near East Lansing, Michigan. Mature borders, completely covered by large trees, were composed of 59 species, the lower strata of which covered an average of 40 percent of the sample areas. The gradual extension of the borders into the surrounding fields was evidenced by the development of a relatively narrow, even-aged stand near the outer portion of the overhanging side branches and a narrow bramble community between the trees and the field. Openings which ranged in size from a mil-acre to one-tenth acre had 57 plant species with the greatest number occurring during the first few years after the openings were made. Openings were closed by the extension of the crowns of trees on the sides of the openings or by the development of seedlings and sprouts within the openings. Time for closure varied from about 4 years to 20 years, depending on the size of the opening and the species which became established in or near it. It was found that 49 plant species were not common to both borders and openings. The interiors of these woodlands had 40 plant species, with the large trees forming a complete cover and the lower strata species 16 percent cover.

The Niacin Content of Fresh and Stored Shell Eggs

Evans, R. J.; Butts, H. A., and Davidson, J. A.

Poultry Sci. 30(1):132-135. 1951 (Journal Article 1169 from the Michigan Agricultural Experiment Station)

Hens kept in laying cages were fed a diet of constant composition. Fifteen consecutive eggs from each of ten hens were used in the study. Samples of three eggs each from each hen were assayed fresh and after 3, 7, and 12 months of

storage for niacin with *Lactobacillus arabinosus*. Fresh shell eggs contained on the average 31.3 μg. of niacin per egg or 0.66 μg. per gm. Most of the niacin (28.5 μg. or 0.93 μg. per gm.) was in the albumen, and only 2.8 μg. (0.16 μg. per gm.) was in the yolk. An average loss of 5.5 μg. of niacin occurred during seven months of cold storage. Despite a loss of water from the eggs, the niacin concentration also decreased to 0.54 μg. per gm. The average niacin content of the yolks of 7-month-old eggs was 4.1 μg., with a concentration of 0.22 μg. per gm. in the yolk and 21.8 μg. (0.74 μg per gm.) in the albumen. Data from 12-month-old eggs could not be used because of spoilage.

The Rate of Absorption of Salt into Different Size Cucumbers

FABIAN, F. W., AND FULDE, R. C.

Food Packer 31, (9) 23, 38, 41, (10) 24, 31. 1950 (Journal Article 1171 from the Michigan Agricultural Experiment Station)

A study was made of the rate of salt penetration from low and high salt brines into cucumbers of different sizes. The concentration of the salt, the size of the cucumbers and the ratio of the brine to the cucumbers affected the rate of salt penetration. Cucumbers salted in low salometer (20 degrees) brine reached equilibrium in approximately eight days for the 600-800 size and in about two days for the 1800 size. When salted in high (40 degrees) salometer brine, in the same time interval, 90 percent of the amount of salt which was absorbed in 8.87 days, was absorbed by the 600-800 size cucumbers in three days; by the 1800 size in about 27 hours; by the 3,000 size in 10.5 hours; by the 4,500 size in 6 hours; by the 10,000 size in 4 hours and by the 18,000 to 30,000 size in about 1.75 hours.

The time required for the cucumbers to absorb the final 10 percent of salt in the 40-degree salometer brine varied with the different size cucumbers. Because the absorption was so small in the different time intervals the amount was difficult to determine accurately even by titration. Irrespective of size, cucumbers contained practically the same amount of salt when they reached equilibrium.

The results of these experiments indicate 1) that there are certain advantages in salting field-run cucumbers as compared with grading them before salting; and 2) why there is more spoilage in the larger size as compared with the smaller sizes since the larger sizes do not have the protective action of salt nearly as quickly as the smaller ones do.

Vibrionic Abortion, a Venereal Disease of Cattle

WEBSTER, H. D., AND THORP, F., JR.

M.S.C. Vet 11(1):23-25, 47. 1950 (Journal Article 1174 from the Michigan Agricultural Experiment Station)

Literature pertaining to the transmission of vibriosis was reviewed. It was shown that *Vibrio fetus* had been isolated from the semen of four bulls. Some of the cows served by these bulls aborted fetuses from which *V. fetus* was isolated.

Preliminary experiments concerning the effectiveness of streptomycin and penicillin against *V. fetus* both in an artificial medium and in embryonating chicken eggs were reported.

The Effects of Continuous Light or Darkness on Thyroid Function in Mice

PUNTRIANO, G., AND MEITES, JOSEPH

Endocrinology 48(2):217-223. 1951 (Journal Article 1177 from the Michigan Agricultural Experiment Station)

The effects of continuous light or darkness for 28 days on thyroid activity were studied in 204 albino mice of both sexes. Continuous light induced significant reductions in a) thyroid weight, b) thyroid reaction to thiouracil and c) thyroid uptake of radioactive iodine (I^{131}). Continuous darkness produced significant increases in a) thyroid weight, b) thyroid reaction to thiouracil and c) thyroid uptake of radioactive iodine. It was concluded, therefore, that continuous light depresses while continuous darkness increases thyroid secretion in mice. Several hypotheses are offered to explain these results.

Effects of Vitamin B_{12} on Thiouracil Action in Rats

MEITES, JOSEPH

Proc. Soc. Exp. Biol. and Med. 75(1):193-195. 1950 (Journal Article 1179 from the Michigan Agricultural Experiment Station)

The effects of crystalline vitamin B_{12} on thiouracil action was determined in immature female rats for a 30-day period. The vitamin completely counteracted the growth-inhibiting action of thiouracil, and this was accompanied by a considerable increase in food consumption. Although vitamin B_{12} decreased the thyroid hypertrophy induced by thiouracil, the uptake of radioactive iodine (I^{131}) by the thyroids was even less than in the rats which received thiouracil only. It is suggested that vitamin B_{12} may be able to induce normal growth in hypothyroid rats.

Effects of Vitamin B_{12} on Normal Thyroid Function in Rats

MEITES, JOSEPH

Proc. Soc. Exp. Biol. and Med. 75(1):195-197. 1950 (Journal Article 1180 from the Michigan Agricultural Experiment Station)

Crystalline vitamin B_{12} was fed to immature rats of both sexes in order to determine whether the vitamin could alter thyroid function in normal or thyroprotein-treated rats. The growth rate of the rats supplemented with the vitamin was increased above that of the normal or thyroprotein-treated controls, but there was no significant effect on thyroid weight or uptake of I^{131}. It is concluded that vitamin B_{12} does not alter normal thyroid activity in rats.

Effects of Vitamin B_{12} on Diethylstilbestrol and Thyroprotein Action in Male Rats

MEITES, JOSEPH, AND SHAY, J. C.

Proc. Soc. Exper. Biol. and Med. 76(1):196-198. 1951 (Journal Article 1184 from the Michigan Agricultural Experiment Station)

The effects of crystalline vitamin B_{12} on several actions of diethylstilbestrol and thyroprotein were determined in 100 young male albino rats. Diethylstilbestrol and thyroprotein were incorporated into the ration in amounts of 0.10 and

0.16 percent respectively, and vitamin B_{12} was injected subcutaneously in doses of 0.2 or 0.4 μg daily. Vitamin B_{12} partially counteracted the growth-retarding action of these two hormones when given individually or together, and also increased food consumption. The vitamins did not alter the ability of diethylstilbestrol or thyroprotein to depress testes weight, or the ability of the former to increase the weight of the seminal vesicles.

Studies on the Heat Inactivation of Cystine in Soy Bean Oil Meal

EVANS, ROBERT JOHN; GROSCHKE, A. C., AND BUTTS, HELEN A.

Archives of Biochemistry 30(2):414-422. 1951. (Journal Article 1189 from the Michigan Agricultural Experiment Station)

Between 31 and 36 percent of the cystine present was destroyed when soybean oil meal was autoclaved for 4 hours at 15 pounds pressure. No destruction occurred when soybean protein or mixtures of soybean protein and sucrose, glucose, dextrin, agar-agar, gum arabic, or soybean oil were autoclaved. Only 13-18 percent of the cystine present in soybean oil meal was available for *Leuconostoc mesenteroides* after digestion with trypsin and erepsin *in vitro*. The proportion of cystine present that was available to this microorganism was not decreased by autoclaving the meal. Nineteen percent of the cystine in soybean protein was available, and autoclaving the protein did not decrease the availability, but none was available after the protein mixed with sucrose or glucose was autoclaved. Cystine seemed to be almost as effective as methionine for supplementing a chick diet containing autoclaved soybean oil meal supplemented with lysine as the sole source of protein.

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